2000 Environmental Surveillance Report

A compilation and explanation of data collected by the INEEL Oversight Program during 2000

State of Idaho, INEEL Oversight Program

Environmental Sampling Coordinators

Air and External Radiation: Luke Paulus

Terrestrial: Luke Paulus

Water: L. Flint Hall

Water Verification: David Frederick

Quality Assurance/Quality Control Coordinator

Kristi Moser

Radiological Analysis Coordinator

Dr. Tom Gesell

Idaho State University

Nonradiological Analysis Coordinator

Barry Pharaoh

IDHW Bureau of Laboratories

Idaho Falls

900 N. Skyline Dr. Ste C
Idaho Falls, ID 83402
Ph. (208) 528-2600
Fax: (208) 528-2605

Boise

1410 N. Hilton
Boise, ID 83706
Ph. (208) 373-0498
Fax: (208) 373-0429

World Wide Web

http://www.oversight.state.id.us
Toll Free: 1-800-232-4635

This report was funded by a grant from the U. S. Department of Energy, Grant No. DE-FG07-001D-13952

Abstract

After completing an independent assessment of the environmental conditions during 2000 in the vicinity of the Idaho National Engineering and Environmental Laboratory (INEEL), the State of Idaho's INEEL Oversight Program (INEEL OP) concluded:

- At monitoring locations on and near the INEEL, gamma radiation measurements remained within background levels.

- While no contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley groundwater monitoring sites, INEEL impacts can be identified at some well sites along the southern boundary of the INEEL. Tritium was detected above background levels, but the concentrations were less than one percent of the EPA drinking water limit.

- Results from contaminants in groundwater and soil from past releases and airborne tritium from 2000 emissions remained well below regulatory limits, with the exception of some on-site groundwater results measuring above drinking water standards. Contaminants detected in groundwater at the INEEL include gross beta radioactivity, strontium-90, Plutonium 238, 239/240, and chromium; however, none of these wells were used for consumption of water by humans or animals.

- The wastewater and groundwater verification program for on-site locations shows that most of the INEEL OP data correlate well with data from the primary contractor, Argonne National Laboratory-West, and the Naval Reactors Facility.

- Analytical data reported by surveillance programs of the INEEL OP and the U.S. Department of Energy generally agree.

The state of Idaho and collaborating organizations will continue monitoring conditions at and near the INEEL to assess potential impacts on public health and the environment.

Table of Contents

Chapter 6

Chapter 7

Chapter 8

Figures

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 7

Tables

Chapter 2

Chapter 3

Chapter 5

Chapter 6

Chapter 7

Executive Summary
INEEL OP Environmental Surveillance Program 2000 Results

Introduction

To determine the impacts that INEEL activities may have on public health and the environment, the State of Idaho maintains the INEEL Oversight Program (INEEL OP). The INEEL OP is designed to provide independent assessments of potential contaminants resulting from DOE activities at the site. It monitors the condition of air, water, external radiation, and soil within the boundaries of the INEEL and air, water, external radiation, soil, and milk at off-site locations. Data from these environmental surveillance efforts are initially reported by the INEEL OP on a quarterly and annual basis, and later compiled with data collected from previous years to identify any discernible trends. The INEEL OP's independent findings are used to compare with and supplement data reported by DOE surveillance programs.

Several organizations were responsible for carrying out the DOE's environmental surveillance program at the INEEL during 2000. Bechtel BWXT Idaho, LLC (BBWI) measured external gamma radiation and analyzed environmental samples of air, drinking water, and soil within the boundaries of the INEEL, and performed limited sampling offsite.

The S.M. Stoller Corporation[1] (ESER) provided environmental surveillance outside the boundaries of the INEEL, and to a limited extent, within the boundaries. Environmental measurements made by ESER included external radiation, analysis of airborne particulate matter, water (drinking and surface), animal tissue, foodstuffs (milk, potatoes, wheat, and lettuce), and soil. Argonne National Laboratory-West (ANL-W) performed the monitoring at that facility, and Bechtel Bettis conducted monitoring at the Naval Reactors Facility (NRF). Groundwater

[1] S.M. Stoller Corporation (ESER) took over the offsite contract in November, 2000. Prior to November, the Environmental Science and Research Foundation (ESRF) had the contract.

surveillance was conducted primarily by the United States Geological Survey (USGS), which samples aquifer wells on the INEEL and throughout the Eastern Snake River Plain.

The INEEL OP does not attempt to duplicate the DOE's extensive surveillance network. Instead, select locations are sampled to provide an overview of the environment on and around the INEEL. Comparison with DOE's data is accomplished by analyzing samples of air, soil, milk, and water collected at the same place and approximate time. In those instances where the INEEL OP collects samples at different locations and/or with different instruments, the subsequent results supplement data collected by the other organizations.

The following sections and tables briefly describe the INEEL OP's environmental surveillance programs, summarize the 2000 surveillance results, discuss identified trends, and present comparisons of the data reported by the INEEL OP and various DOE monitoring programs.

Air and External Radiation Monitoring

Air Monitoring-Particulate Matter and Gaseous Radionuclide

Monitoring Network and Instrumentation

In 2000, the INEEL OP operated 10 air monitoring stations strategically located on and around the INEEL. Air monitoring data for samples collected at an air monitoring station in Fort Hall operated by the Shoshone-Bannock Tribes are also included for this report. At all 11 locations, intermediate flow PM_{10} samplers operate continuously, collecting particulate matter with an aerodynamic diameter less than 10 micrometers. A charcoal cartridge designed to adsorb gaseous radioiodine is placed in series following the particulate filter within each PM_{10} sampler.

Sample Collection Methods and Analysis

On a weekly basis, INEEL OP staff collected the filters and charcoal cartridges from the PM_{10} samplers. Filter analyses involved gas-flow proportional counting techniques to measure gross alpha and gross beta radioactivity. Charcoal cartridges were analyzed with gamma spectroscopy to detect gamma-emitting radionuclides, with specific reporting of iodine-131. On a quarterly basis, the filters were also composited by location and analyzed with gamma spectroscopy for man-made, gamma-emitting radionuclides, with specific reporting of ruthenium/rhodium-106, antimony-125, cesium-134, and cesium-137. PM_{10} samples from all four quarters of 2000 were then composited by location and analyzed for strontium-90, plutonium-238, plutonium-239/240, and americium-241.

Results, Trends, and Interprogram Comparisons

Air monitoring results for 2000 are summarized below, as are any trends identified through the evaluation of air monitoring data collected by the INEEL OP since 1994. In addition, these results are compared to those reported by BBWI and DOE's offsite contractor for the four air monitoring stations that are co-located with those operated by INEEL OP.

Gross Alpha and Gross Beta Radioactivity

Particulate air samples collected during 2000 showed concentrations of airborne radioactivity at typical historical background values. However, elevated concentrations of gross alpha activity were observed during the period of dust storms following the large range fires in the summer of 2000. Because no man-made radionuclides were identified in routine air samples or in supplemental "grab" samples collected during and immediately following the range fires, elevated concentrations of gross alpha activity observed at onsite and boundary locations in August are attributed to the re-suspension of long-lived radon progeny. Elevated concentrations of gross beta activity were observed at all of the monitoring sites during the first week of January and during the last weeks of December. At all on-site, boundary, and distant locations, the 2000 atmospheric concentrations of gross beta are most likely due to naturally occurring radon decay products. The elevated gross beta measurements at the end of the year were likely due to a temperature inversion that held radon progeny in the lower portion of the atmosphere. These conclusions are supported by gamma spectroscopy and radiochemical analyses results discussed below.

Trend analysis of gross alpha and gross beta radioactivity data collected by the INEEL OP since 1994 shows that both measurements fluctuate following seasonal patterns at each of the sample sites.

Direct comparisons of gross alpha and beta screening measurements with other programs were difficult to quantify due to variations in air-sampling methodologies between these programs.

Radioiodine

No iodine-131 was detected on charcoal cartridges collected in 2000, and none has been detected since the INEEL OP began air sampling in 1994. Similarly, the DOE monitoring programs did not report any iodine-131 during the 2000 sampling period.

Gamma Spectroscopy Results

Gamma spectroscopy performed on the 2000 quarterly composited particulate filters detected no man-made, gamma-emitting radionuclides above minimum detectable concentrations (MDC).

Naturally occurring beryllium-7, a cosmogenic radionuclide, was reported exceeding the detection capability of the laboratory. The levels of beryllium-7 concentrations were consistent for each sampling period at on-site, boundary, and distant locations.

Radiochemical Results

No measurable quantities of strontium-90, americium-241, plutonium-238, or plutonium-239/240 were reported for the 2000 annual composite PM_{10} air filters.

Air Monitoring - Atmospheric Moisture and Precipitation

Monitoring Network and Instrumentation

In 2000, the INEEL OP operated 10 atmospheric moisture sampling stations strategically located on and around the INEEL. Atmospheric moisture data collected at Ft. Hall are included in this report. At all 11 locations, air samplers containing cartridges filled with molecular sieve beads were co-located with the PM_{10} air monitoring stations. The beads adsorb and retain moisture from air drawn through the cartridges by a pump.

Additionally, six of the eleven atmospheric moisture sampling stations are equipped with vessels to collect precipitation.

Sample Collection Methods and Analysis

The molecular sieve beads were collected at the end of each quarter, or when the beads had almost reached saturation, whichever occurred first. Moisture removed from the beads was analyzed for tritium, a radioactive isotope of hydrogen. Precipitation was collected quarterly or whenever the container was nearly full, whichever occurred first, and was analyzed for tritium and gamma-emitting radionuclides.

Results, Trends, and Interprogram Comparisons

Tritium

Tritium was detected in atmospheric moisture samples at three on-site monitoring locations (Experimental Field Station, Big Lost River Rest Area, and Van Buren Avenue). The tritium concentrations observed onsite are significantly below levels that would pose a risk to human health. Each program follows slightly different protocols for monitoring extremely low concentrations of tritium in the atmosphere. Different adsorbents, different sampling periods, and other interprogram variables complicate direct comparisons between programs. Differences between INEEL OP and BBWI atmospheric concentrations are likely due to different, but equally valid, analytical techniques and sampling schedules. Differences between INEEL OP and ESER atmospheric concentrations are due to differences in adsorbent media, analytical techniques, and sampling schedules used by individual monitoring programs. While there are differences in results, they are not significant in view of the minute concentrations reported by all three monitoring groups. Neither ESER nor INEEL OP detected tritium in precipitation. BBWI and INEEL OP do not have co-located precipitation sampling sites.

Gamma Spectroscopy Results

Precipitation samples collected during 2000 did not show measurable concentrations of man-made, gamma-emitting radionuclides, as has been the case since 1994, when the INEEL OP began collecting precipitation. Because BBWI and INEEL OP precipitation sampling sites are not co-located, a comparison of data was not conducted. However, INEEL OP and ESER have one co-located site for precipitation, and neither program detected any measurable concentrations of man-made, gamma-emitting radionuclides.

External Radiation Monitoring

Monitoring Network and Instrumentation

In 2000, the INEEL OP maintained a network of 10 stations equipped with high-pressure ion chambers (HPICs), which continuously measure environmental penetrating radiation levels from natural cosmic and terrestrial sources, as well as from operations at the INEEL. Environmental radiation data collected at Fort Hall were also reported. At each of the radiation monitoring stations, Electret Ion Chambers (EICs) were deployed to provide a cumulative total of radiation exposure for the calendar quarter.

Measurement and Analysis

Penetrating radiation levels measured by the HPICs were compiled to provide daily, weekly, monthly, and quarterly average exposure rates. EICs were collected and analyzed quarterly.

Results, Trends, and Interprogram Comparisons

Penetrating radiation readings from the HPICs were consistent with historic background levels measured by the INEEL OP. Because these instruments are not co-located with DOE's, a comparison could not be made.

Penetrating radiation readings for the EICs were also consistent with historical background results. Although the results reported by the INEEL OP, BBWI, and ESER in 2000 fell within levels accepted as background, direct comparisons of the programs' results reflect interprogram variation from different measurement schedules and monitoring techniques. Also, EICs used by INEEL OP are slightly more responsive to low-energy gamma and x-ray photons than the TLDs used by other organizations and show slightly higher exposures.

Terrestrial Monitoring

Monitoring Network and Instrumentation

Milk was collected monthly at five processing plants in southeastern Idaho and the Magic Valley. These plants processed milk from dairies located both near and distant from the INEEL boundary.

Soil samples were collected from nine of eleven sites where INEEL OP maintains gamma radiation monitoring equipment and at other selected locations.

Sample Collection Methods and Analysis

Milk samples were collected from fresh dairy shipments and analyzed using standard gamma spectroscopic methods. Iodine-131 and naturally occurring potassium-40 results are always reported, while other gamma-emitters are reported only if they exceed detection limits.

For each site, soil samples were collected at two depths, 0-5 cm and 5-10 cm, and analyzed with gamma spectroscopy for potassium-40, bismuth-214, lead-214, and actinium-228, which are naturally occurring and typically detected in soil samples. The samples are also analyzed for man-made cesium-137 and other gamma-emitting radionuclides. Cesium-137 is reported whether or not it exceeds detection limits.

Results, Trends, and Interprogram Comparisons

Naturally occurring potassium-40 was the only radionuclide detected in milk samples. Levels were consistent with concentrations measured by the INEEL OP in the past. The reported concentrations of iodine-131 have been less than the minimum detectable concentration for the past five collection years. Likewise the ESER milk monitoring program did not detect iodine-131 over this same period.

Several *in-situ* measurements were made using a portable, high-resolution gamma detector with a multi-channel analyzer. These measurements were made as part of a special study examining the correlation between *in-situ* measurements and traditional soil sampling techniques used by INEEL OP. Some discrepancies were expected between gamma spectroscopic results due to analytical differences; but, the cesium-137 concentrations reported by BBWI and INEEL OP correlated relatively well.

Water Monitoring

Monitoring Network and Instrumentation

The INEEL OP monitors water quality at 88 locations: 28 groundwater and surface water sites on and around the INEEL, 5 drinking water sites and springs distant from the INEEL, and 55 groundwater and springs in the Magic Valley. The 28 INEEL sites, 5 distant sites, and 18 Magic Valley sites are sampled each year. INEEL OP also co-samples with the DOE's primary contractor, the monitoring group at ANL-W, and NRF at 12 wastewater locations and 18 groundwater locations on the INEEL.

Sample Collection Methods and Analysis

Water samples are collected and analyzed not only to detect contaminants known to have been disposed at INEEL facilities, but also to compare with and supplement INEEL data and provide information on general water quality.

Results, Trends, and Interprogram Comparisons

Nonradiological Constituents

Calcium, chloride, magnesium, potassium, sodium, sulfate, total nitrogen and total phosphorus, are known INEEL waste constituents that were detected above background levels in 2000 at some wells within known contamination plumes on the INEEL. However, none of the samples collected by the INEEL OP since 1994 exceeded the drinking water standards for these constituents.

Trace metals, barium, chromium, lead, manganese, and zinc were detected above background levels in samples collected within known groundwater contaminant plumes on the INEEL. Only chromium exceeded the maximum contaminant level (MCL), and only at one well that is not used for drinking water. Barium was detected above background at wells near the Idaho Nuclear Technology and Engineering Center (INTEC) and the Central Facilities Area (CFA). Chromium was above background levels in several wells on the INEEL due to historic wastewater disposal at the Test Reactor Area (TRA) and INTEC. Elevated levels of lead, manganese, and zinc may be attributable to well construction materials, existing natural concentrations in the environment, and INEEL activities. These findings are consistent with results reported by INEEL OP since 1994. During 2000, replicate samples for nonradiological constituent analysis were collected with the USGS at 28 groundwater and surface water locations on and near the INEEL, and at 5 distant locations. The INEEL OP and ESER co-sampled at three springs and two drinking water supply wells south of the INEEL and in the Magic Valley. Comparisons of nonradiological data reported by the INEEL OP and the USGS show excellent agreement for all replicate data.

The nonradiological results reported by the INEEL OP for the verification monitoring program were generally similar to the results reported by ANL-W, NRF, and the DOE's primary contractor at the INEEL. Replicate sample pairs for chloride, copper, nitrate, sulfate, total dissolved solids, and total suspended solids that failed the comparison criteria were wastewater samples. Differences in results were generally attributed to sample heterogeneity, differences in analytical methods, or in some cases the failure to consider sample interference by the analysis laboratory.

Radiological Constituents

Gross alpha screening measurements exceeded detection limits for samples collected at 12 locations during 2000. Gross alpha radioactivity measured was well below the MCL and within expected background levels.

Concentrations of gross beta radioactivity were detected above background in samples from on-site wells. The highest concentrations were observed for two wells known to be impacted by INEEL wastewater. Radiochemical analyses of selected samples from these on-site wells indicate that strontium-90 is the primary source of the gross beta radioactivity. Although strontium-90 exceeded the drinking water standard at one of these wells, the well is not used for drinking water.

Analyses were also conducted for gamma emitters and technetium-99. No gamma emitters were detected except for naturally occurring potassium-40 at nine sites. Technetium-99, a fission product created in nuclear reactors, was detected in samples collected from five wells on the INEEL.

Concentrations of tritium caused by historical waste-disposal practices were detected at levels near, but below, the drinking water standard at several INEEL wells. Overall, tritium concentrations appear to be decreasing within the identified plume. Elevated levels of tritium measured in wells at the Radioactive Waste Management Complex (RWMC) have remained fairly constant since INEEL OP began sampling. At off-site wells near the southern INEEL boundary, tritium has been detected at levels above background, but those levels are only about one percent of the drinking water standard.

Concentrations of Pu-238, 239/240 were detected in samples from a monitoring well near the subsurface disposal area (SDA). Re-analyses of those samples failed to confirm the detection. The samples were taken as part of a special study that included two monitoring wells near the SDA. Both wells will be added to the INEEL OP verification sampling program in 2001.

The INEEL OP collected replicate samples in 2000 with the U.S. Geological Survey (USGS) on and near the INEEL, and south of the INEEL to the Snake River Canyon between Twin Falls and Hagerman. Replicate samples were also available for the five locations where the INEEL OP co-samples with ESER in Magic Valley. In general, the INEEL OP's radiological sample results showed good agreement with data reported by co-sampling organizations. Excellent agreement was noted for all nonradiological parameters. Although statistically significant differences were observed for gross alpha and gross beta radioactivity, cesium-137, strontium-90, and tritium, these differences were relatively small compared to the concentrations observed. Data from co-sampled locations showing the greatest relative differences were strongly influenced by differences in analytical methods and sampling practices.

For the verification program, gross alpha and gross beta results were the only radioactivity analyses that did not meet the comparison criteria. The differences in the gross alpha analyses are attributed to normal analytical variability or sample heterogeneity. INEEL OP gross beta results are consistently lower than the contractor data. The cause for this bias is under investigation by INEEL OP.

Chapter 1
Introduction

Oversight Program Mission and Environmental Surveillance Program

The mission of the State of Idaho's Idaho National Engineering and Environmental Laboratory Oversight Program (INEEL OP) is to provide the people of Idaho with independent, factual information about the INEEL, to help ensure the safety of the citizens of Idaho through the protection of public health and the environment, and to provide statewide radiological expertise. In partial fulfillment of this mission, the INEEL OP developed an Environmental Surveillance Program with the following objectives:

- Maintain an independent, professional environmental surveillance program designed to verify and supplement U.S. Department of Energy (DOE) surveillance programs.
- Provide the citizens of Idaho with information that has been independently evaluated to enable them to reach informed conclusions regarding the potential impacts of present and future DOE activities in Idaho.

This report documents the 2000 findings, developments, and conclusions of the INEEL OP Environmental Surveillance Program.

This annual report is intended to address the question: What is the impact of the INEEL on public health and the environment? The information provided herein represents the surveillance data resulting from environmental measurements made by the State of Idaho's INEEL OP on and around the INEEL during 2000.

The purpose of the INEEL OP Environmental Surveillance Program (ESP), in accordance with the agency's history, initial design, and developmental goals, is to verify and selectively supplement surveillance information gathered by other surveillance programs, including the U.S. Geological Survey (USGS) and DOE-associated programs conducted by Bechtel BWXT Idaho, LLC (BBWI), Argonne National Laboratory-West (ANL-W), Bechtel-Bettis Naval Reactors Facility (NRF), the S.M. Stoller Corporation and ESRF (prior to November 2000.)

Each of these organizations performs monitoring tasks of defined scope; collectively, these programs gather data on a broad variety of media. To both substantiate and augment the results reported by these surveillance programs, the INEEL OP measures external gamma radiation and samples air, precipitation, surface water, groundwater, wastewater, soil, and milk at a number of strategically selected sites. The INEEL OP maintains monitoring locations separate from the other organizations to compile independent measurement results, conduct autonomous evaluations of results, and develop data trends. Also, the INEEL OP collects environmental samples throughout the year at many of the same sites and when possible at the same time as the other surveillance programs. The independence of both the primary and comparative results is preserved by the INEEL OP's contracting the analytical services of two laboratories not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the State of Idaho Department of Health and Welfare Bureau of Laboratories in Boise (IBL).

The INEEL OP's annual findings, developments, and conclusions are presented in the following sections:

Environmental Surveillance Program Scope and Affiliations:

Includes descriptive outline of the full scope of the INEEL OP's environmental surveillance program, including detailed material regarding monitoring locations, instrumentation, methodologies used for sampling and analyses, associated laboratories, and interprogram relationships between the INEEL OP, DOE, and other organizations.

Air, Gamma Radiation, Terrestrial, and Water Monitoring Results:

Includes individual sections containing the 2000 data for each subsidiary of the INEEL OP network; discussions of identifiable trends; comparisons of 2000 data to previously collected data; and comparisons of INEEL OP results to those reported by DOE and other surveillance programs.

Conclusion:

A summation of the program's critical findings.

Appendices:

Addenda which contain further clarification on specific topics addressed in the preceding sections:

Appendix A--initial development and design of the INEEL OP Environmental Surveillance Program.

Appendix B--glossary of technical terms and units used in this report.

Detailed tables of laboratory results from collected samples are available in either printed or electronic formats, and can be requested by contacting at 1-800-232-4635, or:

State of Idaho,
INEEL Oversight Program
900 N. Skyline, Suite C
Idaho Falls, ID 83402

Sampling results and special studies may also be downloaded from the INEEL Oversight Program's website at: http://www.oversight.state.id.us

Chapter 2
Environmental Surveillance Program Scope and Affiliations

INEEL Oversight Program Environmental Surveillance Program History and Legislative Authority

The INEEL OP was created at a time when there was growing concern about environmental contamination from nuclear activities at DOE facilities in several states across the nation. In the late 1980s, the U.S. Secretary of Energy proposed the concept of an oversight role for states hosting these DOE facilities. According to this proposal, states would receive funding and information that would enable them to independently assess environmental conditions and activities at DOE facilities. In 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL. In May 1990, the State and DOE signed a five-year Environmental Oversight and Monitoring Agreement. This agreement, which has subsequently been renewed for two additional, five-year periods, funded the State's INEEL OP and set forth the following responsibilities:

- Secure independent data and information regarding DOE activities in Idaho;
- Scientifically evaluate information on INEEL impacts to the public and environment, and
- Independently report conclusions to the people of Idaho.

The INEEL Oversight Program (INEEL OP)

The INEEL OP's environmental surveillance network on and around the INEEL generates data that can be used to verify and supplement the results reported by several DOE contractors, BBWI, ANL-W, and ESER, as well as results published by the USGS.

The scope of the INEEL OP's network has expanded as goals and objectives for the program have evolved, as described in the history of the network's design and development provided in **Appendix A**.

Currently, the INEEL OP monitors multiple environmental media which have been or potentially could be contaminated by activities at the INEEL, including air, external gamma radiation, soil, milk, surface water, and groundwater.

Independent sampling is performed at selected, strategic locations. As summarized in **Table 2-1**, samples collected from these locations are routinely analyzed for a variety of constituents, and the analytical results compiled from this data form an independent base of scientific findings that can be used to verify results reported by DOE and other surveillance programs.

To maintain the independent status of all INEEL OP results, the INEEL OP contracts analytical services from two laboratories which are not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the Idaho Bureau of Laboratories in Boise (IBL).

The ISU EML is the primary provider of radiological analytical services to the INEEL OP. Located in the Physics Department of the university, the laboratory performs analyses that include screening of gross alpha and gross beta radioactivity, gamma spectroscopy, and liquid scintillation counting for tritium. Environmental samples requiring radiochemical analyses or other specific analyses are contracted out to other laboratories by the ISU EML. ISU EML is also involved in other aspects of the INEEL OP Environmental Surveillance Program, including conducting applied research, providing technical guidance, assisting with program design, and providing student interns who participate in field sampling and data analysis.

The IBL is the primary provider for the non-radiological analyses of INEEL OP surface water and groundwater samples. For these samples, the laboratory supplies results on a suite of nonradiological analytes, including common ions, trace metals, nutrients, and volatile organic compounds (VOCs).

Each laboratory maintains an internal quality control program to ensure consistency and accuracy, and to provide a means of assessing the quality of the data reported. Should a laboratory note a concern that could potentially affect the quality of the data, the INEEL OP may assign a data qualifier to the analytical results for a particular sample, depending on the severity of the problem. During data validation, an analytical result may be rejected or accepted as an estimate, in accordance with protocols developed by the EPA. These quality control practices ensure that only the most representative data are reported.

Other Surveillance Programs

Bechtel BWXT Idaho, LLC (BBWI)

As the INEEL operating contractor for the DOE, BBWI is responsible for collecting and analyzing radiological and nonradiological samples for the Site Environmental Surveillance Program. BBWI conducts on-site monitoring of air, water, soil, and vegetation, with some limited off-site sampling for comparative purposes. The Radiological Measurement Laboratory (RML) at the TRA performs the majority of analytical services for BBWI.

Table 2-1. INEEL OP Environmental Surveillance Program (ESP) Summary, 2000

Media Sampled Type of Analysis	Locations and Frequency[a]			Minimum Detectable Quantities
	On-Site	**Boundary**	**Off-Site**	
Air				
PM_{10} Samplers				
Alpha	4 W	4 W	2 W	0.001 pCi/m^3
Beta	4 W	4 W	2 W	0.001 pCi/m^3
Gamma	4 Q[b]	4 Q[b]	2 Q[b]	0.003 pCi/m^3 (Cs-137)
Radiochemical[c]	4 A[b]	4 A[b]	2 A[b]	Varies
Charcoal Cartridges				
Iodine-131	4 W	4 W	2 W	0.006 pCi/m^3
Atmospheric Moisture				
Tritium	4 Q	4 Q	3 Q	1 pCi/m^3
Precipitation				
Tritium	1 Q	4 Q	1 Q	160 pCi/L
Gamma	1 Q	4 Q	1 Q	6 pCi/L (Cs-137)
Gamma Radiation				
High-Pressurized Ion Chambers (HPIC)				
Gamma (μR/hr) (continuous readings)	5	5	1	1.4 (μR/hr)
Environmental Dosimeters (EIC)[g]	7Q	4Q	3Q	10 mR (estimated from typical 2 sigma)
Terrestrial: Milk				
Gamma Spectroscopy				
Iodine-131			5 M	4 pCi/L
Terrestrial: Soil				
Gamma Spectroscopy[d]	3 A	2 A		0.01 pCi/g (Cs-137)

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) Summary, 2000

Media Sampled Type of Analysis		Locations and Frequency[a] On-Site	Boundary	Off-Site	Minimum Detectable Quantities
Water: Radiological					
	Alpha	33 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	2-5 pCi/L
	Beta	33 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	2-3 pCi/L
	Gamma (Cesium-137)	33 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	6-10 pCi/L
	Tritium	23 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	160 pCi/L (15-20 pCi/L for electrolytically enriched)
	Sr-90	11 S[e]			3-4 pCi/L
	Tc-99	4 S[e]			4-5 pCi/L
Water: Non-radiological					
Common Ions					
	Total Alkalinity	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	1.0 mg/L
	Calcium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
	Chloride	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	2.0 mg/L
	Fluoride	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
	Magnesium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.05 mg/L
	Potassium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
	Sodium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
	Sulfate	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	2-4.5 mg/L
Nutrients					
	Nitrate + Nitrite as Nitrogen	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.005 mg/L
	Nitrogen (ammonia)	23 A			0.005 mg/L
	Nitrogen (Kjeldahl)	23 A			0.05 mg/L
	Phosphorus	15 Q/S[e] 23 A	13 Q/S[e,g]	5 A	0.05 mg/L
Trace Metals					
	Aluminum	23 A			50 μg/L
	Antimony	23 A			5 μg/L
	Arsenic	23 A			10 μg/L
	Barium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	1 μg/L
	Beryllium	23 A			1 μg/L
	Cadmium	23 A			100 μg/L
	Chromium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	2 μg/L
	Cobalt	23 A			5 μg/L
	Copper	23 A			10 μg/L
	Iron	23 A			10-20 μg/L
	Lead	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	5 μg/L
	Manganese	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	10 μg/L
	Mercury	23 A			0.5 μg/L
	Nickel	23 A			10 μg/L

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) Summary, 2000

Media Sampled Type of Analysis	Locations and Frequency[a]			Minimum Detectable Quantities
	On-Site	Boundary	Off-Site	
Selenium	23 A			5 µg/L
Silver	23 A			1 µg/L
Thallium	23 A			1.5 µg/L
Vanadium	23 A			10 µg/L
Zinc	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	5 µg/L
Volatile Organic Compounds	5 A			0.5 µg/L

a. Sample frequency: W – weekly, M – monthly, Q – quarterly, S – semiannually, A – annually, T–triennially
b Quarterly and annual analyses performed on composited weekly samples for each location.
c. Radiochemical analyses include screening for Pu-238, Pu-239/240, Am- 241, and Sr-90.
d. Gamma spectroscopy of soil samples includes examination of the spectra specifically for the man-made gamma-emitters Cs-137 and Co-60 and the naturally occurring gamma-emitters Bi-214, Pb-214, and Ac-228. Other radionuclides occurring above the detection limit will be identified by the analysis software.
e. Quarterly and semi-annual sampling schedules with varied frequencies.
f. Includes three surface water sites.
g. There are 82 locations throughout

The S.M. Stoller Corporation (ESER)

In November 2000, DOE awarded the off-site monitoring, under the Environmental Surveillance Education and Research contract, to the S.M. Stoller Corporation (ESER). ESER also performs some limited on-site monitoring. Currently, ESER results applicable to interagency comparisons include those for samples collected from the air and external radiation measurements, and samples of ground and surface water, soil, and milk. In an effort to maintain independence, ESER employs the services of the ISU Environmental Assessment Laboratory (ISU EAL), which remains separate from the ISU EML, for radiological analyses, and contracts with an outside laboratory for radiochemical analyses.

Previous to November 2000, the Environmental Science and Research Foundation conducted the off-site monitoring for DOE.

United States Geological Survey (USGS)

As part of the long-term collection of hydrological and geological data related to the presence and movement of radioactive and nonradioactive constituents in groundwater, the USGS conducts ground and surface water monitoring both on and off the INEEL. Samples collected by the USGS on and near the INEEL are analyzed by the DOE Radiological and Environmental Sciences Laboratory (RESL), and by the USGS National Water Quality Laboratory in Arvada, Colorado. Analytical results are presented in USGS reports.

Argonne National Laboratory (ANL-W)

The University of Chicago operates Argonne National Laboratory, with facilities in Illinois (ANL-E) and Idaho (ANL-W), for DOE. As a separate organization from BBWI, ANL-W operates its own environmental sampling program. Quanttera, Severn Trent Laboratory, St. Louis, and Paragon perform some of ANL-W's analyses, as well as an on-site laboratory.

NRF

NRF is operated for the Naval Nuclear Propulsion Program, an integrated program of the Departments of Energy and Navy by Bechtel Bettis, Inc. As a separate organization from BBWI, NRF operates its own environmental sampling program. Acculabs, Severn Trent Laboratory, the University of Richland and Denver, Georgia Center for Applied Isotope Study, and USGS perform some of NRF's analyses.

Shoshone-Bannock Tribes

The Shoshone-Bannock Tribes operate a community air monitoring station at Fort Hall similar in design and complement of instruments to the INEEL OP community monitoring stations. These samples are also analyzed by the ISU EML.

The INEEL OP Sampling Network and Co-Sampling Strategies

Air Monitoring

Air samples collected by the INEEL OP in 2000 were screened for gross alpha and gross beta radioactivity, and analyzed for tritium in atmospheric moisture, and gamma radioactivity. Radiochemical analyses were performed on air filters for strontium-90 (Sr-90), plutonium-238 and plutonium 239/240 (Pu-238, 239/240), and americium-241(Am-241). Typically, the INEEL OP reports all results for gross alpha and beta radioactivity, but notes only those gamma spectroscopy results exceeding the minimum detectable concentration (MDC). As part of gamma spectroscopic analyses, specific results are reported by the laboratory for Ru/Rh-106, Sb-125, Cs-134, and Cs-137.

Air Monitoring Locations

Extensive studies of the semi-arid climate and complex wind patterns of the Eastern Snake River Plain strongly influenced the placement of the stations in the original INEEL OP air monitoring network. From an initial six monitoring sites in 1992, the Environmental Surveillance Program has expanded to include the ten air monitoring stations identified in **Figure 2-1**. Currently, each of these stations is equipped with instruments to collect airborne particulate matter, gaseous radioiodine, and water vapor. Six stations are equipped to collect precipitation. The INEEL OP also reports air monitoring data for samples collected at a station in Fort Hall operated by the Shoshone-Bannock Tribes.

Each monitoring station is categorized by location as on-site, boundary, or distant. **Table 2-2** lists the sample types, frequency, and analyses conducted by the INEEL OP for each location, and also identifies the comparable schedule and analysis activities for other agencies sampling at each location.

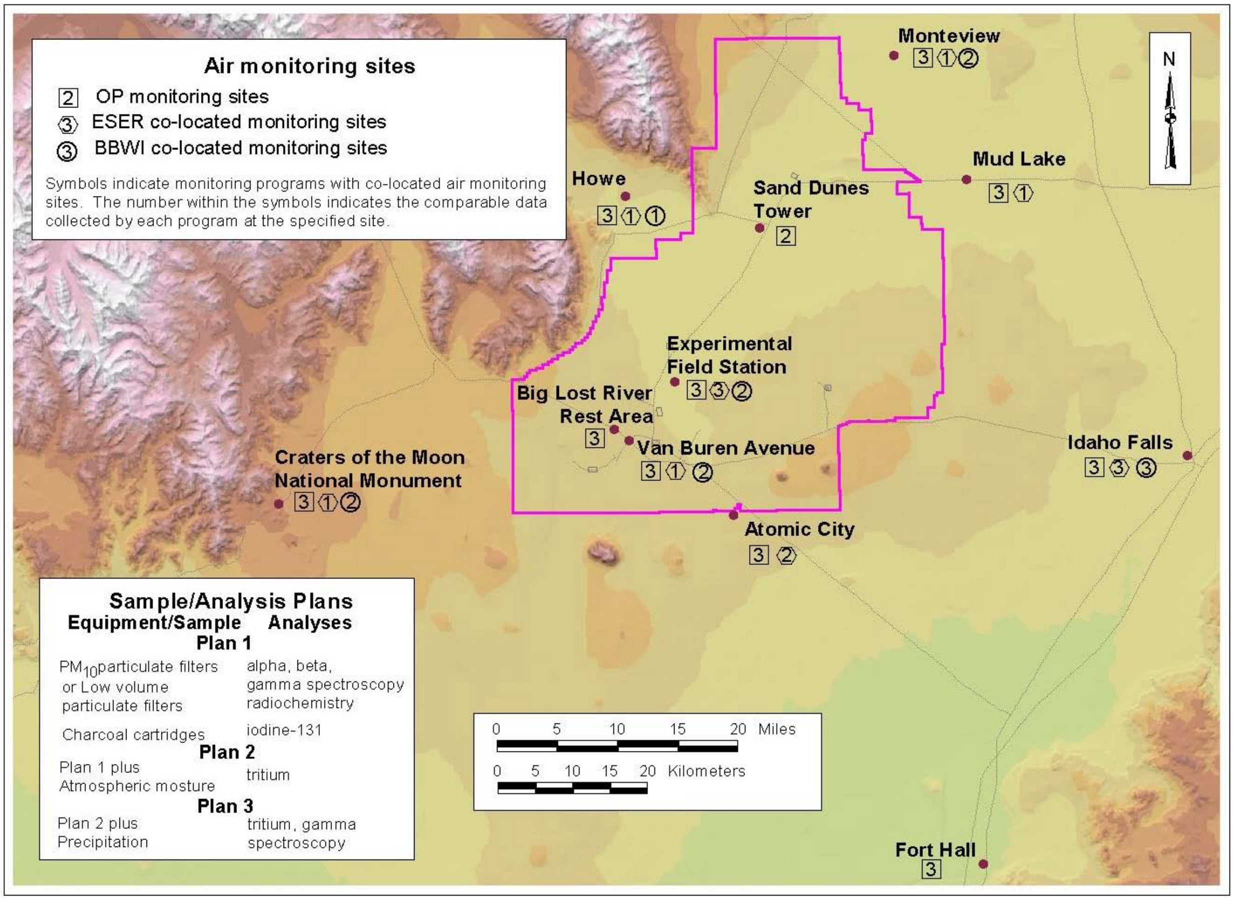

Figure 2-1. Air Monitoring Locations.

Air Monitoring Equipment and Procedures

Air Samplers

Intermediate-flow PM_{10} samplers operate continuously at each of the air monitoring stations to collect particulate matter measuring less than ten micrometers in aerodynamic diameter. Each sample is collected on a 4-inch Versapore membrane filter. Filters are collected weekly and stored for approximately five days in a desiccator to allow for the radioactive decay of short-lived radon progeny prior to gross alpha and gross beta radioactivity screening analyses. PM_{10} filter samples are analyzed for gross alpha and gross beta radioactivity using a thin window, gas-flow proportional counter.

To collect gaseous radioiodines, primarily iodine-131 (I-131), an activated charcoal sorbent cartridge is placed directly in line behind the particulate air filter in each PM_{10} sampler. The charcoal cartridges are analyzed weekly in a batch process using gamma spectroscopy. Each batch includes the cartridges collected from 10 sampling locations, placed in a 4-L Marinelli beaker in a reproducible geometry. If I-131 is detected in a batch of cartridges, then the cartridges can be analyzed individually.

During 2000, the particulate filters and charcoal cartridges were collected and analyzed according to the schedules outlined in **Table 2-2**. Following weekly individual analyses for gross alpha and beta radioactivity, filters were composited by location for quarterly analyses of specific radionuclides by gamma spectroscopy.

To obtain additional data for the evaluation of trends in air quality, the INEEL OP has introduced annual radiochemical analyses of the particulate air filters. From 1996 to the present, the particulate filters have been composited annually by location and sent to a commercial laboratory for radiochemical analyses of Sr-90, Pu-238, Pu-239/240, and Am-241.

Precipitation Samplers

Six of the INEEL OP air monitoring stations are equipped to collect precipitation samples for radiological analyses. The precipitation is collected on a one-meter, square metal tray attached to a polyethylene collection vessel. At the end of each quarter or when the collection vessel is nearly full, whichever occurs first, the precipitation samples are collected, composited by quarter if necessary, and analyzed for tritium and gamma-emitting radionuclides, as shown in **Table 2-2.**

Atmospheric Moisture Samplers

Atmospheric moisture is collected at eleven of the monitoring stations by passing air through a column containing a mixture of molecular sieve beads and indicating molecular sieve beads, which are capable of removing and storing moisture from the air. As indicated in **Table 2-2**, the samples are collected when the beads nearly reach saturation or at the end of each quarter, whichever occurs first. Heating the beads releases the moisture, which is then collected as condensation and analyzed for tritium using liquid scintillation counting techniques.

Air Monitoring Quality Assurance/ Quality Control

Quality control for the air monitoring program is maintained through adherence to the INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all field air sampling measurements and laboratory analyses. Air flow rates and volume measurements for particulate samplers and atmospheric moisture samplers in the field receive annual performance evaluations. Air sample results are reviewed for adequate sample volume before final results are calculated.

Quality control checks also involve the preparation of external field blanks and internal laboratory protocols. Field blanks are prepared weekly for the air particulate filters and quarterly for atmospheric moisture samples. The laboratory's internal protocols include instrument performance checks, sample recounts, and cross-check programs. Any QA/QC sample results that impact the evaluation of interprogram comparisons are identified in the individual data results chapters; however, QA/QC protocol are described in more detail in a separate annual Quality Assurance/Quality Control Report.

Table 2-2. Interprogram air monitoring sampling/analyses schedules, 2000

Co-located Sampling Instrumentation, Scheduling, and Analyses				
Equipment/Sample Types	**Particulate Air Sampling**	**Charcoal Cartridges**	**Atmospheric Moisture**	**Precipitation**
Frequency of Sampling	**Weekly**	**Weekly**	**Quarterly[e]**	**Quarterly[f]**
Analyses[a, b]	**Alpha, Beta, Gamma Radiochemistry[d]**	**Iodine-131[c]**	**Tritium**	**Tritium, Gamma**
On-site Locations/Organization*				
Experimental Field Station	OP ST BB	OP ST BB	OP ST BB	ST
Sand Dunes	OP	OP	OP	
Van Buren Avenue	OP ST BB	OP ST BB	OP BB	
Big Lost River Rest Area	OP	OP	OP	OP
Boundary Locations/Organization*				
Atomic City	OP ST	OP ST	OP ST	OP
Howe	OP ST BB	OP ST BB	OP	OP
Monteview	OP ST	OP ST	OP	OP
Mud Lake	OP ST BB	OP ST BB	OP	OP
Distant Locations/Organization*				
Idaho Falls	OP ST BB	OP ST BB	OP ST	OP ST
Craters of the Moon	OP ST BB	OP ST BB	OP BB	
Fort Hall	SB	SB	OP	

*Sampling Organization Abbreviations:
OP = INEEL OP ST = ESER/ESRF BB = BBWI SB = Shoshone-Bannock Tribes

a. The INEEL OP samples the PM_{10} fraction of airborne particulate matter; ESER and BBWI sample total particulate matter.
b. Identifies all INEEL OP analyses and those co-sampling agency analyses used for comparisons of results.
c. Samples composited by location and analyzed by gamma spectroscopy on different schedules.
d Samples composited by location and analyzed by radiochemical techniques for Pu-238, Pu-239/240, Am-241, and Sr-90 on different schedules.
e Samples are collected quarterly or when beads reach saturation.
f Samples are collected quarterly or when sample container is full, whichever occurs first.

Interprogram Air Sampling Results and Comparisons

As indicated in **Figure 2-1**, the INEEL OP, BBWI, and ESER conducted co-located sampling activities throughout 2000, with each organization separately performing the range of scheduled analyses identified. In this report, the results of INEEL OP measurements are compared directly to those of the two DOE monitoring programs.

Each organization performing air sampling as part of its respective surveillance program collects airborne particulate matter, but collection equipment varies slightly. The INEEL OP uses intermediate flow PM_{10} samplers; ESER and BBWI use low-volume particulate air samplers.

Each agency performing air sampling conducts gross alpha and gross beta radioactivity screening analyses, gamma spectroscopic analyses of composite filter samples, and radiochemical analyses of composite filter samples, although radiochemical analyses are done on different schedules on samples from different locations by the various organizations. Each group collects radioiodine samples using activated charcoal cartridges that are analyzed by gamma spectroscopy for iodine-131.

The sampling schedules, analyses, and instruments used by the participating agencies are listed in **Table 2-2**. The INEEL OP and BBWI each collected particulate, radioiodine, and composite atmospheric moisture samples at four identical or nearby locations. The INEEL OP and ESER collected particulate, radioiodine, and composite atmospheric moisture samples at four identical or nearby locations.

Linear regressions, Quantile-Quantile plots, and paired t-tests were the primary statistical tools used to compare the gross alpha, gross beta, and gamma spectroscopy results from these locations. Comparison results are presented in the Air Monitoring Results section later in this report.

Environmental Radiation Monitoring

The INEEL OP uses a combination of instruments that measure the environmental radiation levels from natural cosmic and terrestrial sources as well as from possible contributions from operations at the INEEL. The INEEL OP can therefore report the results of measurements of both time-dependent exposure and time-integrated exposure to environmental gamma radiation.

Gamma Radiation Monitoring Locations

Local climatology and atmospheric dispersion models for the INEEL influenced the selection of the locations for the initial radiation monitoring sites in much the same way that such modeling techniques facilitated the placement of the air monitoring stations. Since 1995, the network has included the 14 stations identified in **Figure 2-2.**

Gamma Radiation Monitoring Equipment and Procedures

The gamma radiation monitoring instrumentation located at each station is listed in **Table 2-3**. The majority of the gamma radiation stations are co-located with air monitoring sites.

Environmental Dosimeters

Environmental dosimetry are deployed at radiation monitoring stations to measure ambient, penetrating radiation exposure. EICs measure cumulative exposure (mR). Average exposure rates (µR/hr) are reported using the cumulative exposure divided by the deployment time. Currently, the INEEL OP uses commercially supplied EICs as the standard dosimeter within the network. The EICs are constructed from carbon-filled polypropylene that offers a nearly air equivalent response. Before deployment, each electret's initial voltage is read in-house, and recorded. The EIC is then packaged in a mylar plastic bag, which is heat sealed. After being labeled, the bag is placed in a tyvek envelope for protection from the weather. At the end of each calendar quarter, the exposed environmental dosimeters are collected, final voltages are read and recorded, and gamma radiation exposures are calculated from the voltage differences and calibration factors.

Table 2-3 External Radiation Monitoring Schedules, 2000.

Instrumentation:	**Environmental Dosimeter (EIC)**	**High-Pressurized Ion Chamber (HPIC)**
Analysis	**Gamma (µR/hr)**	**Gamma (µR/hr)**
On-Site Locations		
Base of Howe Peak	✔	✔
Big Lost River Rest Area	✔	✔
Experimental Field Station	✔	
Main Gate	✔	✔
Rover	✔	✔
Sand Dunes	✔	✔
Van Buren Ave.	✔	
Boundary and Distant Locations		
Atomic City	✔	✔
Big Southern Butte	✔	✔
Howe	✔	✔
Monteview	✔	✔
Mud Lake	✔	✔
Idaho Falls (Distant)	✔	✔
Craters of the Moon (Distant)	✔	

High-Pressure Ion Chambers (HPICs)

At the 11 monitoring sites identified in **Figure 2-2**, high-pressure ion chambers (HPICs) continuously measure the gamma radiation exposure rate in microRoentgens per hour (µR/hr). The generated current is measured every five seconds, and the intensity of the radiation field is determined from the magnitude of the current. The exposure rate is then averaged over five-minute intervals by the data system associated with each HPIC. For data storage and reporting purposes, the five-minute values are further averaged into hourly values.

Each station is equipped with a modem and radio for transmitting the five-minute values to the INEEL OP Idaho Falls office, allowing immediate access to data from individual HPICs. Gaps in data sets collected by radio modem are filled using data collected by data loggers at each station.

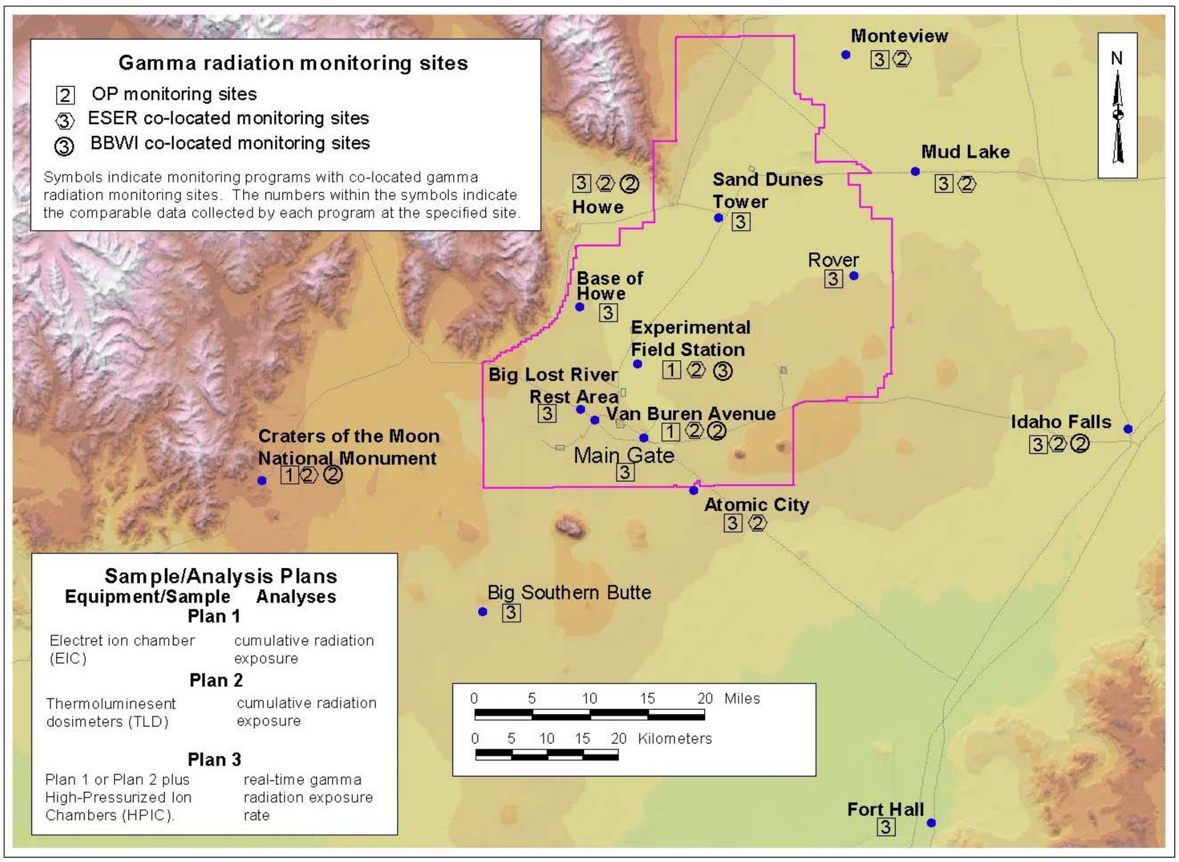

Figure 2-2. Gamma Radiation Monitoring.

Gamma Radiation Monitoring Quality Assurance/ Quality Control

Quality control for the gamma radiation monitoring program is maintained through adherence to the INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all gamma radiation instrumentation and analyses. Each quarter during 2000, INEEL OP had EICs irradiated with known and "blind" gamma exposures. For QA purposes, irradiations of EICs are conducted by ISU EML to a known exposure of 30 milliRoentgen (mR) and a "blind" exposure ranging from 20 to 50 mR. EIC response is considered acceptable if each irradiated EIC agrees within 10% or within 3 standard deviations of the exposure given. In addition, duplicate environmental dosimeters were placed at various radiation monitoring sites during each quarter.

The response of each HPIC is verified annually in the field with a radiation source and a calibrated reference instrument. At every location, side-by-side measurements are made of the source with the reference instrument and with the HPIC. Whenever these measurements do not agree to within 10%, the HPIC is removed and returned to the manufacturer for service and calibration. The analytical techniques and laboratory methods applicable to the above procedures are described in a separate annual Quality Assurance/Quality Control Report.

Interprogram Gamma Radiation Monitoring Results and Comparisons

During 2000, the DOE and the INEEL OP did not co-locate HPICs for gamma radiation measurement. However, INEEL OP co-located EICs with a limited number of TLDs from the other surveillance programs.

Terrestrial Monitoring

Terrestrial environmental surveillance typically includes examination of several mechanisms that tend to collect and/or accumulate radioactive material in the environment. Such mechanisms include the concentration of important nutrients and minerals by cattle during milk production. Cows' milk tends to concentrate iodine, and since cows typically graze over large areas of pasture, radioiodine fallout may be detected in milk at concentrations corresponding to relatively low concentrations in the environment.

The INEEL OP also collects soil samples that are analyzed by gamma spectroscopy for both selected naturally occurring and man-made, gamma-emitting radionuclides. The locations for soil and milk sampling reflect the consideration of potential source terms, their significance, regional meteorology, and monitoring activities by other programs

Terrestrial Monitoring Locations

Milk Sample Collection Sites and Dairy Locations

Milk samples are collected from five processing plants in southeastern Idaho and the Magic Valley (Rupert, Gooding, Rexburg, Blackfoot, and Pocatello). Each plant processes milk produced by dairies in other localities. For example, at the Rexburg plant, the INEEL OP collects milk originally from dairies in the Howe and Mud Lake areas. **Figure 2-3** identifies the five off-site distribution locations sampled by the INEEL OP and indicates the dairies affiliated with each processing plant.

Soil Monitoring Locations

Soil samples are typically collected from 14 sites on, near, and distant from the INEEL. Obtaining these soil samples from permanent monitoring sites potentially allows the INEEL OP to link air and terrestrial measurements. For 2000, soil samples were collected at only nine of the possible 14 locations.

Terrestrial Monitoring Equipment and Procedures

Milk Monitoring

Milk samples are collected from fresh dairy shipments after receipt by milk product processors. Two liter samples are collected from each of the five off-site distribution locations and analyzed by gamma spectroscopy within seven days of collection.

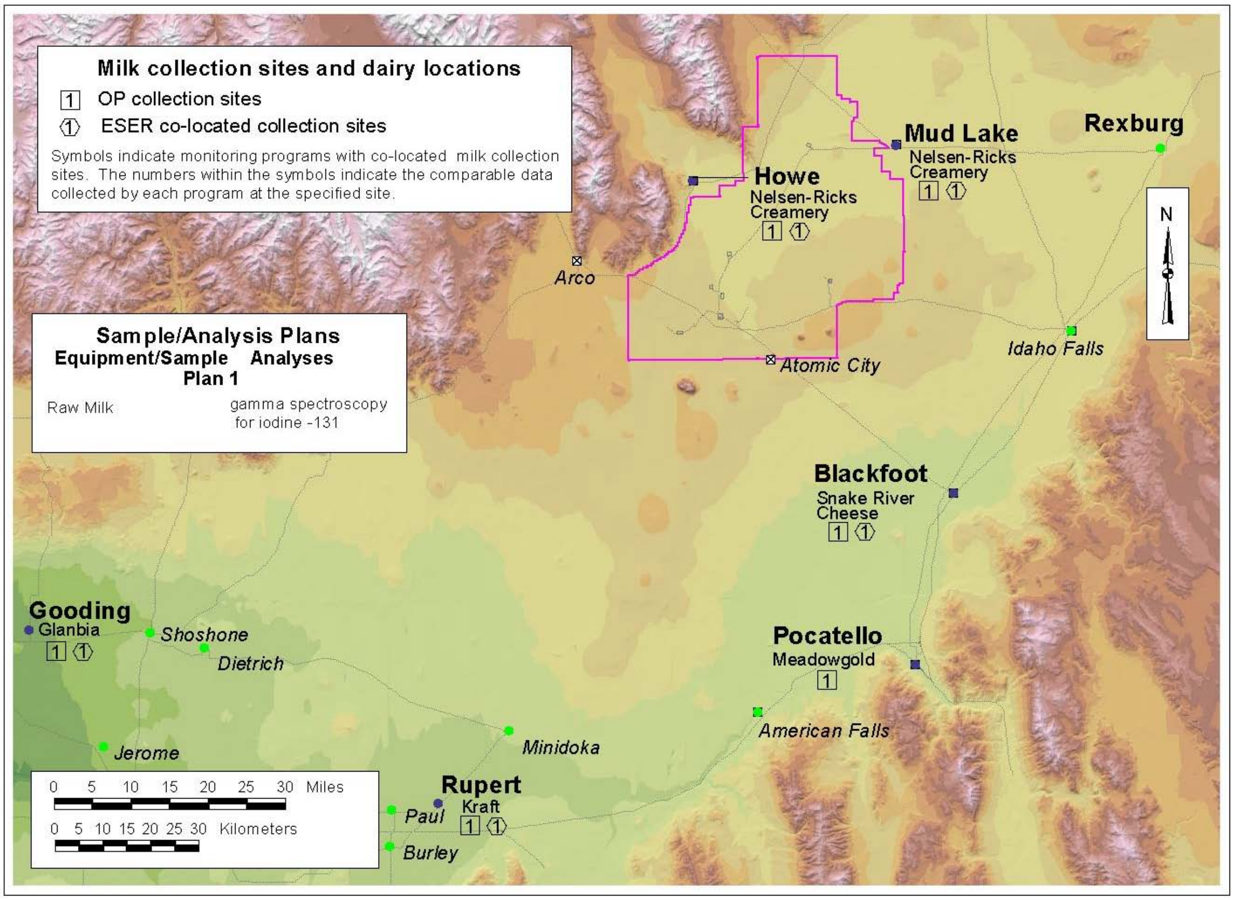

Figure 2-3. Milk Monitoring Locations

Soil Monitoring

Soil samples are collected from undisturbed soil with a stainless-steel sampling ring (4 in. diameter by 2 in. depth [10 by 5 cm]) at two depths: 0-2 in. (0-5 cm) and 2-4 in. (5-10 cm). Five samples are acquired at each depth for specified locations, normally within an area 20 meters in diameter. Consisting of approximately one gallon of soil, which is sieved and homogenized prior to laboratory analysis, these samples are composited separately into two samples representative of the two depth intervals, and analyzed by gamma spectroscopy.

Terrestrial Monitoring Quality Assurance/Quality Control

Quality control for the terrestrial monitoring program is maintained through adherence to the INEEL OP standard operating procedures. Laboratory quality assurance and control methods include the use of soil calibration standards, laboratory-prepared spikes, and other technical practices and protocols.

Interprogram Terrestrial Monitoring Results and Comparisons

As presented in **Figure 2-3**, the INEEL OP and ESER collects milk samples after delivery to the distribution centers. ESER also collects milk samples from the individual milk sources prior to shipment. Linear regressions are used to compare the organization's analytical results for co-located collection sites.

INEEL OP did not co-sample soil with BBWI or ESER during 2000. Hence, no comparison was made.

Water Monitoring

The analyses of water samples collected by the INEEL OP primarily detect contaminants known to have been released as liquid effluents from INEEL facilities, but also measure analytes that characterize general water chemistry. Nonradiological analyses are performed for common ions, nutrients, and dissolved trace metals. Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, Sr-90, Tc-99, uranium, thorium, and Am-241.

Although very few of the wells sampled by the INEEL OP supply drinking water systems, all analytical results are compared to the EPA's maximum contaminant levels (MCL) or secondary maximum contaminant levels (SMCL). A contaminant's MCL defines the maximum permissible level of that contaminant in water, which if consumed at a rate of 2 liters per day over an entire year, would equal the public dose limit.

A contaminant's SMCL identifies the maximum level that contaminant can measure before the aesthetic qualities of the water are impacted. Although the SMCL is an unenforceable limit, concentrations of contaminants that exceed SMCLs may adversely affect the odor, taste, or appearance of water.

As the Eastern Snake River Plain Aquifer has been designated as a “sole source” aquifer, supplying the majority of drinking water for many Idahoans, MCLs and SMCLs provide a useful means of determining if the quality of this very important source of water is at risk.

Starting in 1999, INEEL OP initiated a verification program in which wastewater and groundwater locations on the INEEL were co-sampled with the primary contractor and ANL-W for direct comparison purposes. In 2000 NRF was added to the program. Nonradiological analyses are performed for common ions, nutrients, dissolved trace metals, and volatile organic compounds. Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, and Sr-90.

Water Monitoring Locations

The INEEL OP monitors water quality at a total of 88 separate sampling locations for routine sampling and 30 separate sampling locations for verification. As shown in **Figures 2-4, 2-5,** and **2-6,** the areas of the monitoring locations have been divided into on-site, boundary, distant, Magic Valley, surface water categories. **Table 2-4** specifies the sampling schedules, analyses, and corresponding co-sampling organizations for each of these locations. **Table 2-5** presents the suite of analytes scheduled for samples collected by each agency.

Water Monitoring Equipment and Procedures

The wells sampled by the INEEL OP use dedicated pumps. Prior to each sample collection, the well is pumped to remove standing water in the borehole and any associated plumbing such as the pressure tank and discharge line. During the purge of the well, measurements of the pH, specific conductance, and water temperature are monitored until these parameters stabilize. After these parameters have stabilized and approximately three well-bore volumes have been pumped, the sample is collected, always from the same designated sampling port.

Surface water samples from the Big Lost River, Birch Creek, and the springs distant from the INEEL in Magic Valley are routinely collected in areas of moving water, in order to collect samples representative of the bulk of the stream.

Wastewater and groundwater verification samples were collected with BBWI, NRF, and ANL-W at several locations on the INEEL (**Figure 2-6**).

The samples analyzed for radionuclides, and common ions (with the exception of calcium, magnesium, sodium, and potassium) are unfiltered. Samples selected for dissolved metals analyses, and nutrients (nitrate + nitrites as nitrogen, and total phosphorus) are filtered in the field.

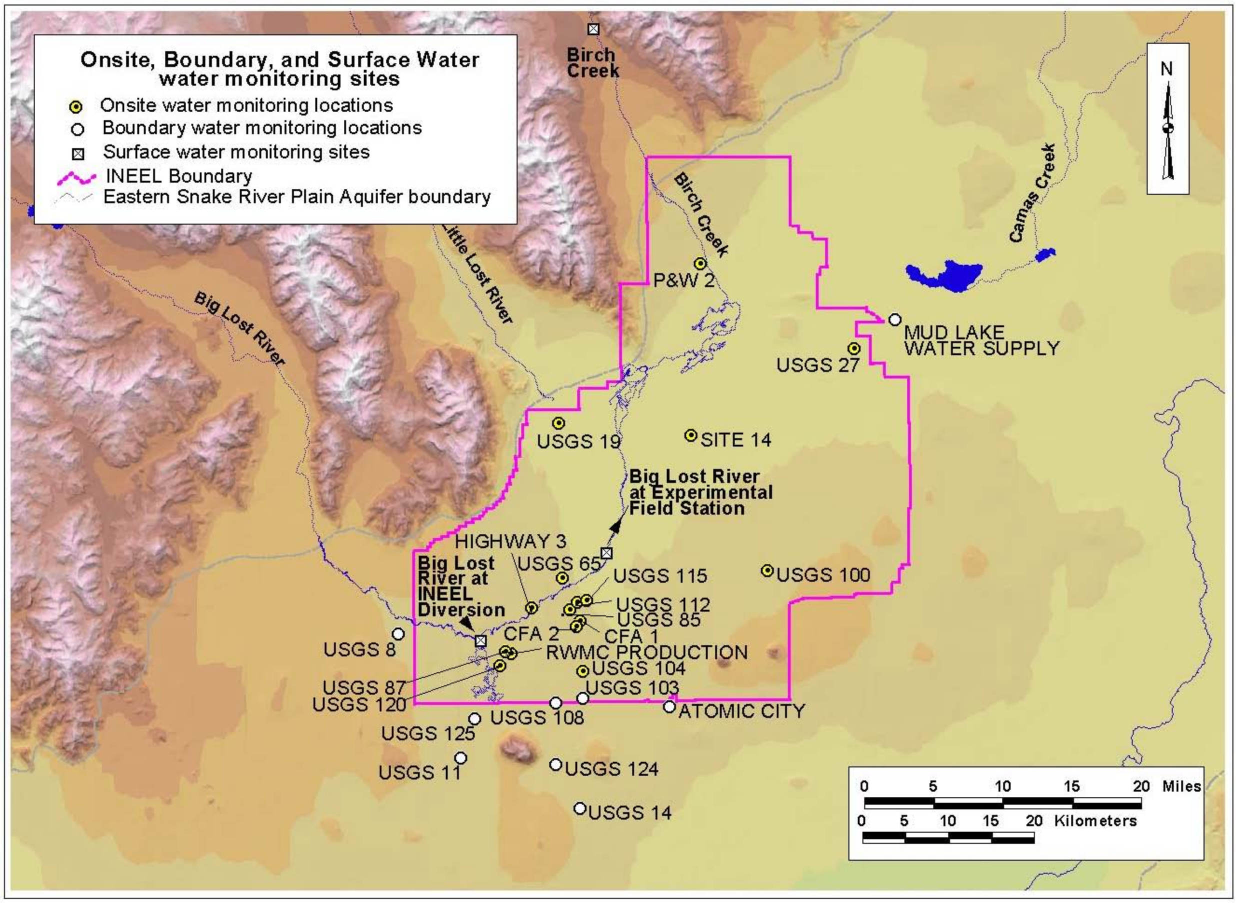

Figure 2-4. On-site and Boundary Water Monitoring Locations

Water Monitoring Quality Assurance/Quality Control

Quality control for the water monitoring program is maintained through adherence to the INEEL OP standard operating procedures. To verify the accuracy and precision of the laboratory analyses, the INEEL OP obtains analytical results of field duplicates of radiological water samples and both field duplicates and spiked samples of non-radiological water samples. These quality assurance results along with results from field blank samples not only indicate whether data qualification will be necessary during data validation, but also identify laboratory problems potentially requiring corrective action.

Interprogram Water Monitoring Results and Comparisons

Comparisons of INEEL OP, ESER, USGS, BBWI, ANL-W, and NRF water results involve the collection of replicate samples—samples collected by two of the six agencies at essentially the same time, typically less than a few minutes apart.

Because goals for the water sampling programs conducted by the INEEL OP, the USGS, and ESER differ somewhat, all samples are not analyzed for exactly the same parameters by all three agencies. As previously discussed, separate laboratories perform these analyses, and certain differences in analytical methods can influence the comparisons of interprogram results. However, in its verification program the INEEL OP analyzes its samples for exactly the same parameters as the primary contractor, ANL-W and the NRF programs.

Linear regressions, paired T-tests, analysis of differences, and relative percent difference calculations are used to compare results. Where the linear regression analysis was meaningful, comparison is defined by the regression slope and intercept. Regressions were considered meaningful where the correlation coefficient, R, was greater than 0.80, the probability that the R could have occurred randomly is small, (p-value approaching 10^{-4}) and the standard deviation of the difference between the actual values and the value predicted by the regression was small relative to the range of the data.

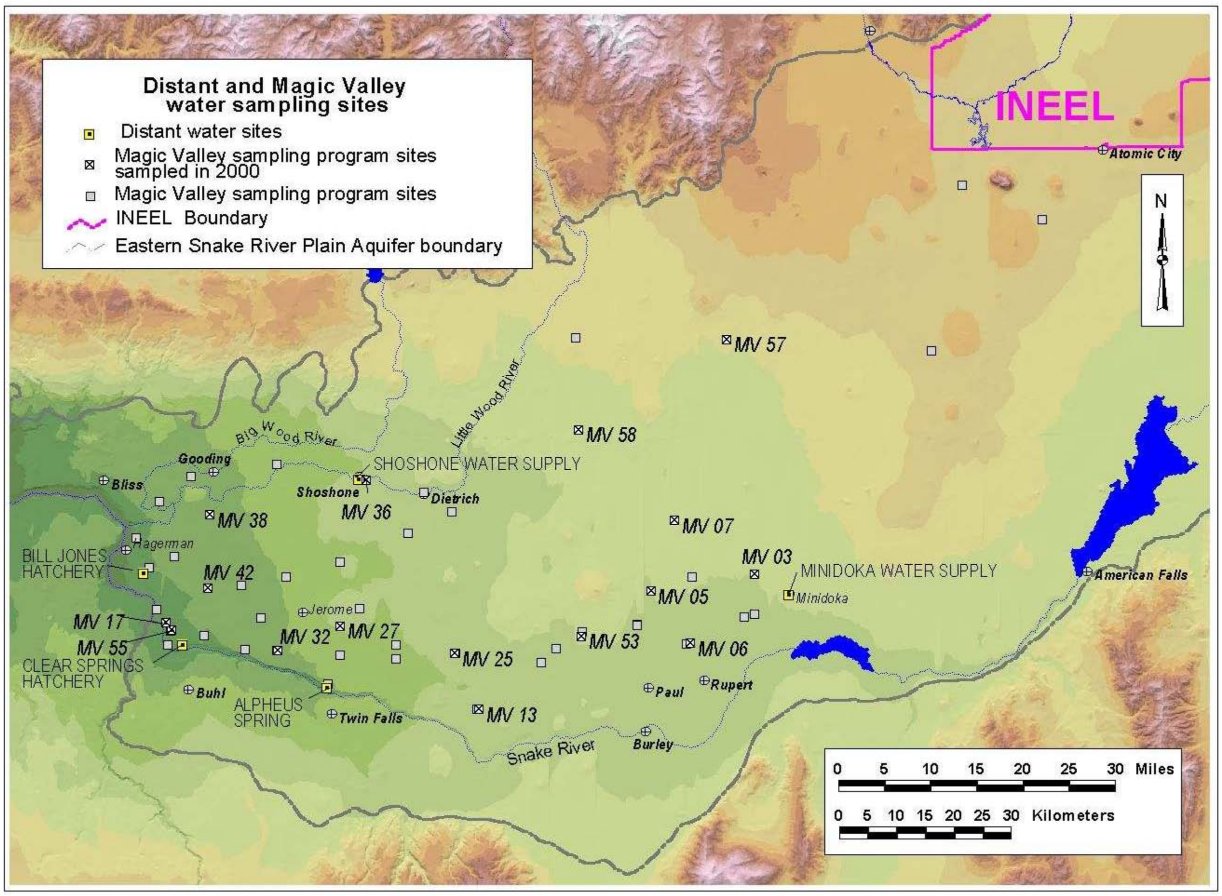

Figure 2-5. Distant and Magic Valley Water Sampling Locations

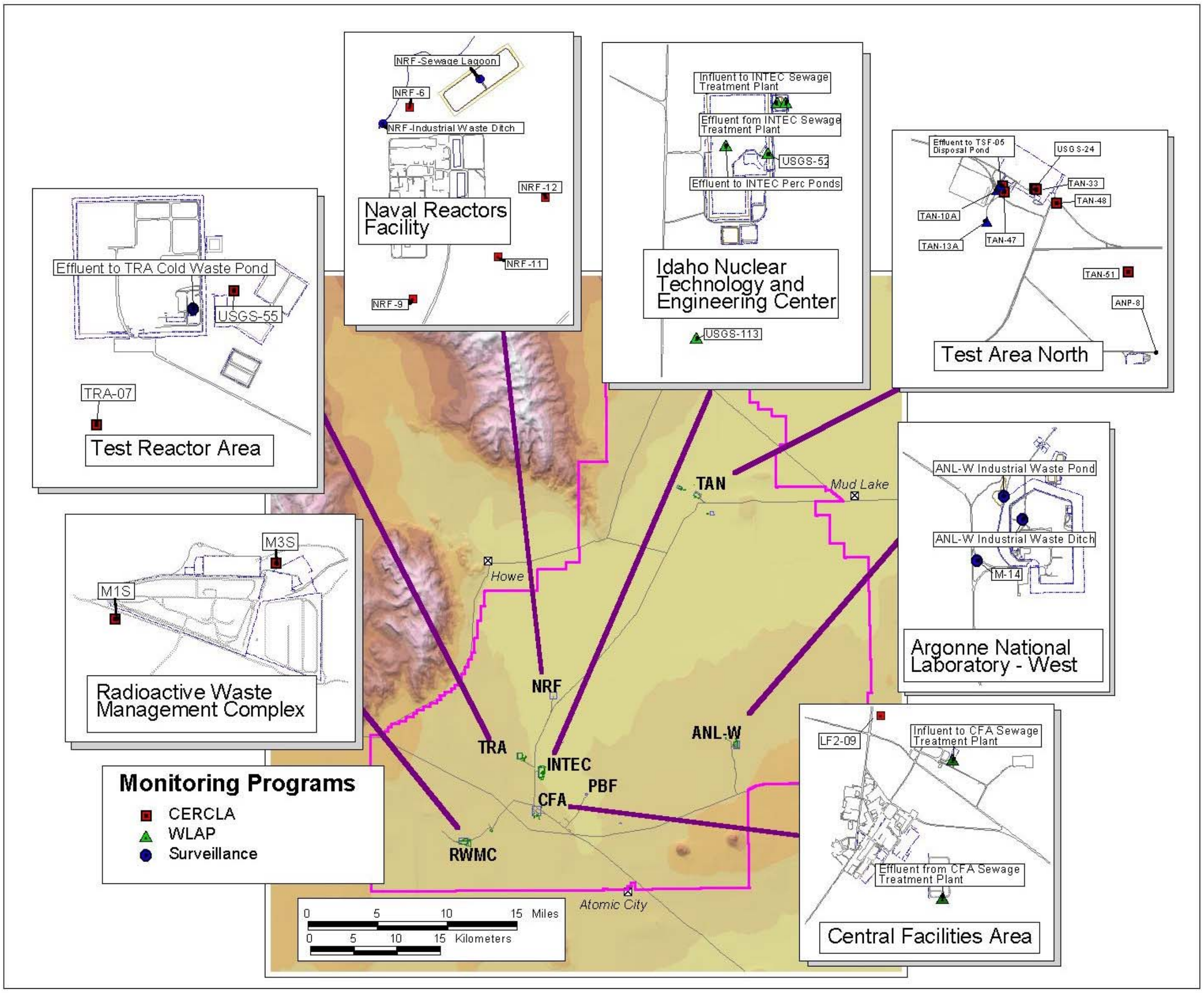

Figure 2-6. Water Verification Monitoring Sites

When regressions were not meaningful, the differences between replicate results were evaluated using t-tests to compare population means and histograms of differences between replicates. Relative percent differences were used for comparison when there were not enough data for comparison by other means. The analytical data for the replicate samples, including results less than the detection limit, are available on request.

Table 2-4. Interprogram water monitoring sampling schedules and analyses, 2000

Co-located/Replicate Sample Analyses		**Radiological**		**Nonradiological**		
Analysis	**Frequency***	**Alpha, Beta, Gamma**	**Tritium**	**Metals**	**Common Ions`**	**Nutrients**
On-site Locations				**Organizations**		
CFA 1	Q	OP	OP USGS	OP USGS	OP USGS	OP USGS
CFA 2	Q	OP	OP USGS	OP USGS	OP USGS	OP USGS
RWMC Production	Q	OP	OP	OP	OP USGS	OP USGS
P&W 2	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
Site 14	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 19	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 27	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 65	Q	OP USGS	OP USGS	OP	OP USGS	OP USGS
USGS 85	S	OP	OP USGS	OP	OP USGS	OP USGS
USGS 87	Q	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 100	S	OP	OP USGS	OP USGS[a]	OP USGS	OP
USGS 104	Q	OP	OP USGS	OP	OP USGS	OP USGS
USGS 112	Q	OP	OP USGS	OP	OP USGS	OP USGS
USGS 115	Q	OP	OP USGS	OP	OP USGS	OP USGS
USGS 120	Q	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
Boundary Locations				**Organizations**		
Atomic City	Q/S	OP	OP USGS	OP	OP USGS	OP USGS
Highway 3	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
Mud Lake Water Supply	Q	OP	OP	OP	OP	OP
USGS 8	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 11	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 14	S	OP USGS	OP USGS	OP USGS[a]	OP USGS[b]	OP USGS
USGS 103	Q	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 108	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 124	S	OP	OP USGS	OP	OP USGS	OP
USGS 125	S	OP	OP USGS	OP USGS[a]	OP USGS	OP USGS
Distant Locations				**Organizations**		
Alpheus Spring	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Bill Jones Hatchery	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Clear Spring	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Minidoka Water Supply	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Shoshone Water Supply	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Magic Valley Sampling Program				**Organizations**		
MV 01	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 02	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 03	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 04	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 05	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 06	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 07	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 09	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 10	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 11	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 12	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 13	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 14	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 15	T	OP USGS[c]	OP USGS	USGS	USGS	USGS

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2000

Co-located/Replicate Sample Analysis		Radiological		Nonradiological		
Analysis	Frequency*	Alpha, Beta, Gamma	Tritium	Metals	Common Ions	Nutrients
MV 16	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 17	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 18	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 19	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 20	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 21	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 23	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 24	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 25	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 26	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 27	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 29	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 30	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 31	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 32	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 33	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 35	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 36	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 37	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 38	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 39	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 40	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 41	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 42	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 43	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 45	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 46	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 47	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 48 (USGS 11)	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 49	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 50	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 51	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 52	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 53	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 54	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 55	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 56	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 57	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 58	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 59	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 61 (USGS 14)	T	OP USGS[c]	OP USGS	USGS	USGS	USGS

Table 2-4 continued. Interprogram water monitoring sampling schedules and analyses, 2000

Co-located/Replicate Sample Analysis		**Radiological**		**Nonradiological**		
Analysis	**Frequency** *	**Alpha, Beta, Gamma**	**Tritium**	**Metals**	**Common Ions**	**Nutrients**
Surface Water Locations		**Organizations**				
Birch Creek at Blue Dome	S	OP	OP USGS	OP	OP USGS	OP USGS
Big Lost River at Experimental Field Station	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
Big Lost River at INEEL Diversion	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS

* Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially
Q/S = Quarterly by OP, semiannually by USGS

** OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.

[a] The USGS samples only for chromium at these locations; the OP samples for all the metals listed in the text.
[b] The USGS samples only for chloride at these location; the OP samples for all the common ions listed in the text.
[c] The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy.

Table 2-5. Verification sampling program's water monitoring schedules and analyses, 2000

		Radiological			**Nonradiological**			
Analyses	**Frequency** *	**Alpha, Beta, Gamma**	**Tritium**	**Sr-90**	**Metals**	**Common Ions**	**Nutrients**	**VOCs**
Wastewater Locations/Organization								
CPP-797	M/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
CPP-796	S/A				OP BBWI	OP BBWI	OP BBWI	
CPP-773	M/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
CFA-LS1	M/A				OP BBWI	OP BBWI	OP BBWI	
CFA-STF	M/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
TAN-655	M/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
TRA-764	Q/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
TRA-608	Q/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
WRRTF-2	S/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	
ANL-W Industrial Waste Ditch	M/A	OP ANL-W			OP ANL-W	OP ANL-W	OP ANL-W	
ANL-W Industrial Waste Pond	M/A	OP ANL-W	OP ANL-W		OP ANL-W	OP ANL-W	OP ANL-W	
Groundwater Locations/Organization								
ANP-8	A/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI
TAN-10A	S/A				OP BBWI	OP BBWI	OP BBWI	
TAN-13A					OP BBWI	OP BBWI	OP BBWI	
TAN-36	A/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI
TAN-37	A/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI
TAN-40	A/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI
TAN-48	A/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI
TRA-07	S/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	
M-14	S/A	OP ANL-W			OP ANL-W	OP ANL-W	OP ANL-W	
USGS 52	S/A				OP BBWI	OP BBWI	OP BBWI	
USGS-55	S/A	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	OP BBWI	
USGS 113	S/A	OP BBWI			OP BBWI	OP BBWI	OP BBWI	

*Sampling Frequency Abbreviations M/A = Monthly by Organization, Annually by OP
Q/A = Quarterly by Organization, Annually by OP
S/A = Semi-annually by Organization, Annually by OP
A/A = Annually by Organization, Annually by OP

Chapter 3

Air Monitoring

Major Findings and Developments

Gross alpha and gross beta radioactivity measurements in air were consistent with historical background concentrations. Atmospheric tritium concentrations and tritium concentrations in precipitation were consistent with the range of historical background concentrations and typically below detection levels.

- No off-site environmental impacts from INEEL operations were detected in particulate air samples.
- Elevated gross alpha screening measurements were observed during periods of dust storms following summer range fires. Elevated gross alpha activity was attributed to the re-suspension of long-lived radon progeny since no man-made radionuclides were identified in routine air samples.
- Radioiodines were not detected in air samples.
- No off-site environmental impacts from INEEL operations were detected in atmospheric moisture samples or precipitation samples.
- Inter-program comparisons of different surveillance program results show relatively good agreement. Discrepancies have been traced to differences in sampling methodologies, schedules, and laboratory detection capabilities.

Primary Air Results and Trends

INEEL OP collects particulate air samples weekly. Particulate air samples collected during 2000 showed concentrations of radioactive material at typical historical background values associated with radionuclides found naturally in the environment. Elevated concentrations of gross alpha

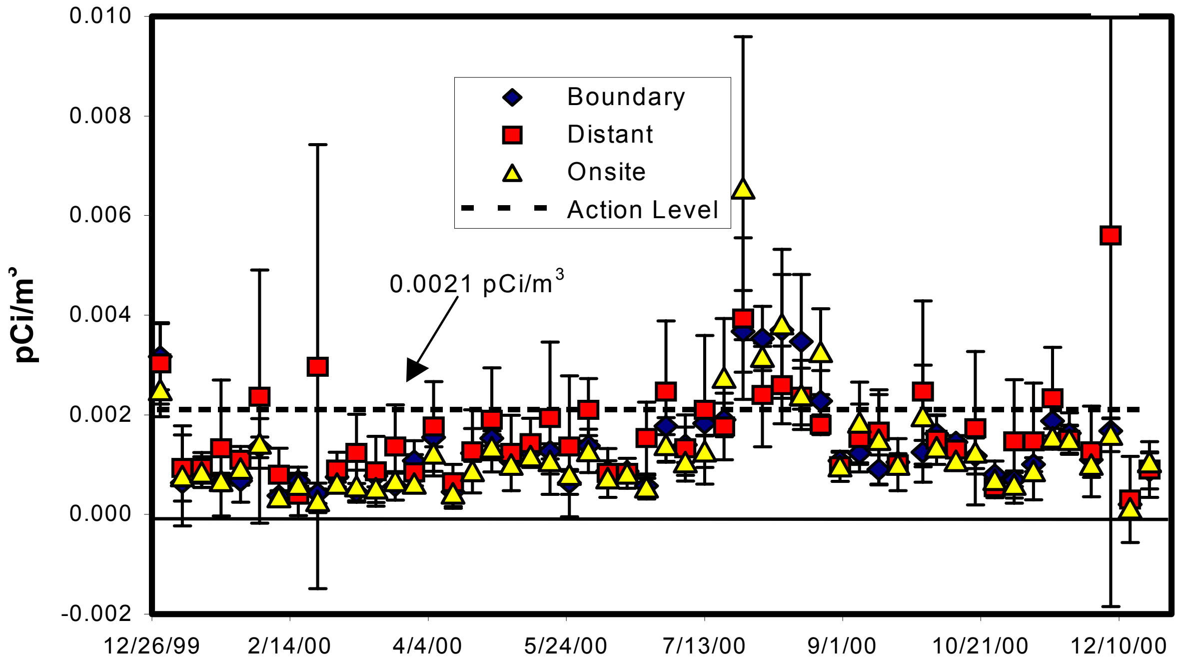

Figure 3-1. Weekly average gross alpha concentrations in particulate air samples collected by INEEL OP using PM_{10} samplers. Action level (0.0021 pCi/m^3) corresponds to a concentration warranting further investigation. This concentration corresponds to 5 mrem per year assuming gross alpha is attributable to Am-241 and the concentration remains constant for one year.

activity (**Figure 3-1**) observed at onsite and boundary locations in August were attributed to the removal of vegetation resulting from a range fire and the subsequent re-suspension of long-lived alpha emitting progeny of radon, specifically polonium-210 and lead-210. Elevated concentrations of gross beta activity (**Figure 3-2**) were observed at all of the monitoring sites during the last weeks of December, 1999, and during the first week of January. Elevated gross beta measurements were attributed to temperature inversions that held radon progeny in the lower portion of the atmosphere. It is highly unlikely that these elevated gross beta measurements were due to INEEL operations since the entire facility was shut down during the holiday break and no man-made radionuclides were identified via gamma spectroscopy or by radiochemical separation.

Additional information regarding the range fires experienced on the INEEL during 2000 is available in INEEL OP document number OP-01-02, *Environmental Monitoring Associated with Range Fires On and Around the INEEL July to August, 2000.*

Weekly air samples are screened for gross alpha and gross beta radioactivity concentrations. Quarterly composites are analyzed via gamma spectroscopy for gamma-emitting radionuclides. Annual composite samples are analyzed using radiochemistry techniques for transuranic radionuclides, including americium-241 (Am-241), plutonium-238 (Pu-238), plutonium-239/240 (Pu-239/240), and strontium-90 (Sr-90).

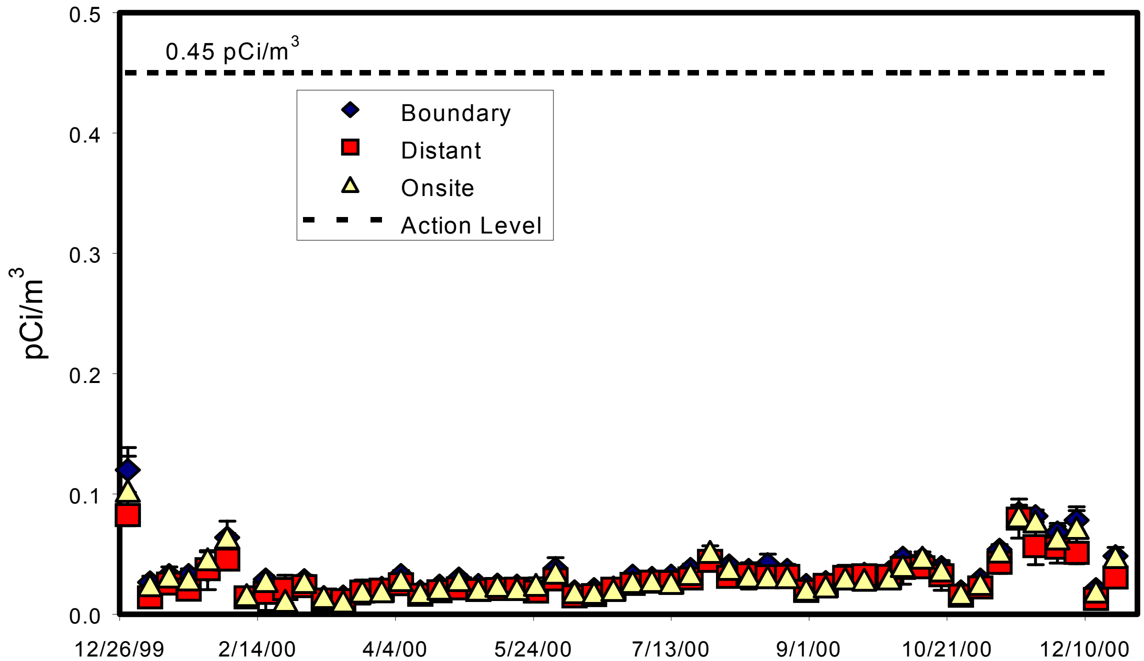

Figure 3-2. Weekly gross beta concentrations in particulate air samples collected by INEEL OP using PM_{10} samplers. Action level (0.45 pCi/m^3) corresponds to a concentration warranting further investigation. The action level concentration corresponds to 1 mrem per year assuming gross beta is attributable to Sr-90 and the concentration remains constant for one year. Elevated gross beta concentrations during the first week of January and the months of November and December are attributed to temperature inversions that trapped radon and its radioactive progeny in the lower atmosphere.

No iodine-131 (I-131) was detected in activated charcoal filters used for sampling radioiodine. As of January 1, 2001, INEEL OP has not observed I-131 in radioiodine samplers.

Atmospheric Moisture and Precipitation

The INEEL OP atmospheric moisture samples and precipitation samples are analyzed for tritium using liquid scintillation counting techniques. Gamma spectroscopy is used to analyze precipitation samples for gamma-emitting radionuclides that may have undergone atmospheric wash out.

The INEEL OP collects atmospheric moisture at 11 sampling locations. Atmospheric tritium results from samplers at Craters of the Moon National Monument, Idaho Falls, and at the Fort Hall Community Monitoring Station are used as reference background if tritium concentrations significantly exceed detection capabilities.

Tritium was detected in atmospheric moisture samples at three on-site monitoring locations (Experimental Field Station, Big Lost River Rest Area, and Van Buren Avenue) during 2000. Measured atmospheric tritium concentrations ranged from 0.5 to 1.5 pCi/m^3. Historically, the detection capabilities for atmospheric tritium have ranged from 0.5 to 5.0 pCi/m^3 depending on humidity, volume of air sampled, and the laboratory MDC for tritium in the atmospheric moisture, **Figure 3-3**. Tritium was not observed in atmospheric moisture samples collected at the other monitoring stations. The tritium concentrations observed onsite are significantly below levels that would pose a risk to human health. Tritium was not detected in precipitation samples collected by INEEL OP during 2000.

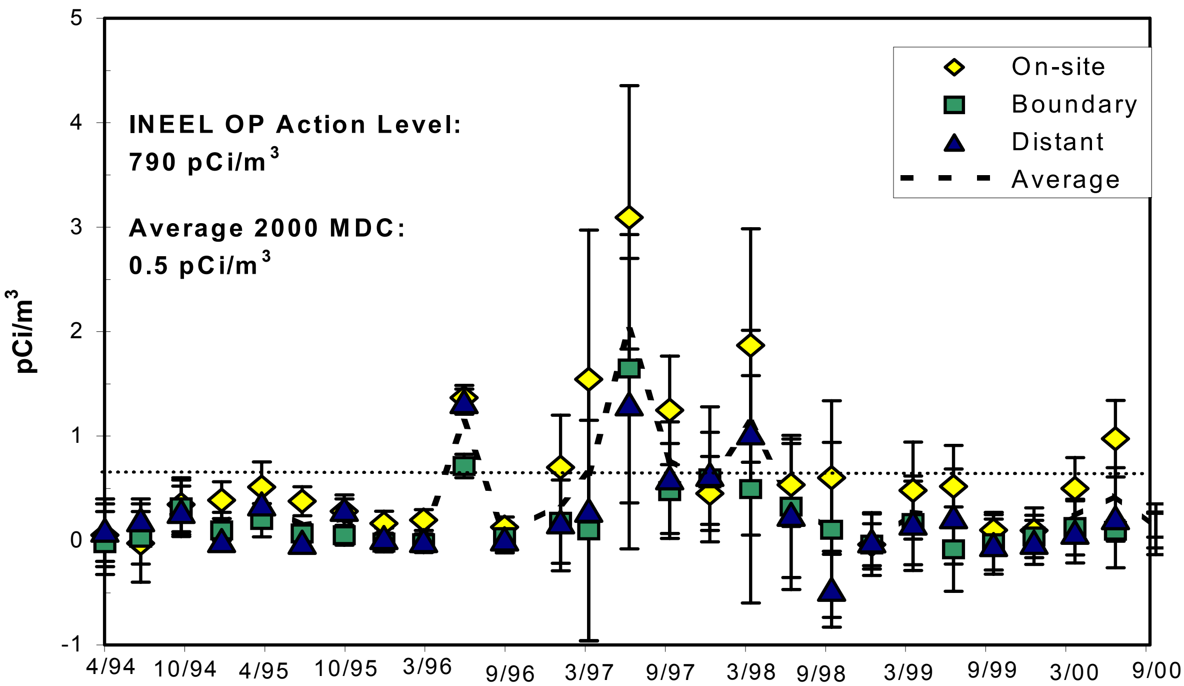

Figure 3-3. Average atmospheric tritium concentrations observed by INEEL OP since 1994. Action level (790 pCi/m^3) is a tritium concentration that corresponds to a total effective dose equivalent of 1 mrem per year assuming the concentration remains constant for one year. MDC varies from 0.5 to 5.0 pCi/m^3 depending upon humidity during sampling period, volume of air sampled, and the laboratory MDC for tritium in water vapor collected.

No man-made gamma-emitting radionuclides were identified in any of the precipitation samples collected by INEEL OP. No tritium was detected in any of the precipitation samples collected by INEEL OP.

Inter-program Comparisons of Air Sampling Results

BBWI, ESER, and INEEL OP conduct gross alpha and gross beta screening analyses of particulate air samples, gamma spectroscopic analyses of activated charcoal air filters (radioiodine filters), gamma spectroscopic analyses of composite particulate air filter samples, and radiochemical analyses of composite particulate air filter samples. Air sampling also involves the collection of atmospheric moisture to determine atmospheric tritium concentrations. Since air-sampling methodologies vary between programs, the results of direct comparisons of screening analyses (e.g., gross alpha and gross beta concentrations in air) are difficult to quantify and interpret. Gamma spectroscopic analyses of composite air filter samples did not show measurable quantities of man-made gamma-emitting radionuclides. Gamma spectroscopic analysis of precipitation and liquid scintillation counting of atmospheric moisture and precipitation for tritium showed similar results. No I-131 was detected in activated charcoal air filters collected by the INEEL OP, BBWI, or ESER during routine environmental surveillance for 2000.

The comparisons of other constituents show relatively poor agreement to relatively good agreement. Variability among the three surveillance programs may be due to differing sampling procedures, sampling schedules, and variations in laboratory analysis procedures. Poor agreement is not entirely unexpected due to the extremely low concentrations reported and variations in natural background. Despite variations in reported analysis results, neither BBWI nor ESER observed significant impacts to the environment as a result of INEEL operations during 2000.

Gross Alpha and Gross Beta Radioactivity Comparison Results

The comparison of gross alpha and gross beta concentrations observed by BBWI with respect to concentrations observed by ESER or INEEL OP was performed using data collected from air monitoring sites located at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue. Craters of the Moon National Monument and Idaho Falls are considered distant sampling locations, whereas the Experimental Field Station and Van Buren Avenue are on-site sampling locations.

INEEL OP also compared its gross alpha and gross beta date with data collected by ESER at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, Van Buren Avenue, Mud Lake, Monteview, Howe, and Atomic City.

Descriptive statistics of gross alpha and gross beta radioactivity results used for comparison purposes are shown in **Table 3-1**. Differences in gross screening results are attributable to differences in sampling methods, sampling schedules, and laboratory analysis methods.

Table 3-1. Descriptive statistics for comparison of gross screening measurements for particulate air filters collected by INEEL OP, ESER, and BBWI.

	INEEL OP Gross Alpha (pCi/m^3)	ESER Gross Alpha (pCi/m^3)	BBWI Gross Alpha (pCi/m^3)
Average:	0.0012	0.0016	0.0008
Median:	0.0010	0.0013	0.0007
Standard Deviation:	0.0009	0.0011	0.0015
Range:	-0.0002 to 0.0087	0.0001 to 0.0074	-0.0017 to 0.0120
	Gross Beta (pCi/m^3)	**Gross Beta (pCi/m^3)**	**Gross Beta (pCi/m^3)**
Average:	0.031	0.027	0.025
Median:	0.027	0.023	0.023
Standard Deviation	0.017	0.013	0.011
Range:	0.008 to 0.097	0.002 to 0.090	0.006 to 0.067

Gross alpha and gross beta analyses of particulate air samples are screening tools. As screening analyses, specific radionuclides are not identified and measurements are not decay corrected. Mass absorption corrections, due to impracticality, are not performed. However, while these variations will frequently indicate statistical differences between data sets, quantitative comparison methods make it possible to evaluate the agreement between results.

To determine data correlation between programs, INEEL OP examines the relative difference between one measurement and the mean of the both programs' measurements. If the absolute value of the relative difference is less than 10% or the two reported values are within 3-standard deviations of the reported uncertainty, the results are considered to be in agreement. Agreement is considered "good" if at least 80% of the paired samples meet these criteria. Discrepancies are expected due to differences in sampling schedules and sampling methodology. Results of these comparisons are shown in **Table 3-2**.

Table 3-2. Direct comparison results of gross screening measurements of particulate air filters

	Average Relative Difference	Percent of Results in Agreement	Number Sample Results Compared
Gross Alpha Activity			
INEEL OP vs BBWI	NA[a]	87.3%	192
INEEL OP vs ESER	NA[a]	93.5%	398
BBWI vs ESER	NA[a]	61.8%	199
Gross Beta Activity			
INEEL OP vs BBWI	-9.1%	72.9%	
INEEL OP vs ESER	-8.9%	76.4%	
BBWI vs ESER	2.5%	87.9%	

[a] NA – not an appropriate comparison due to large uncertainty terms associated with measurements.

Quantile-Quantile plots are used to provide a qualitative comparison between analysis results observed by the different monitoring programs. Gross alpha and gross beta activity measurements observed by each monitoring program are assumed to be randomly collected from the same data set, which is not necessarily normally distributed. If the data from each sampling program are collected from the same sample population, the resultant plot should show a linear relationship with a slope approaching unity (i.e., 1.0). Deviations from a linear correlation indicate that the data are not collected from the same population. A slope other than 1.0 indicates a sampling bias in the sample data collected from the population set.

In cases where there is enough activity to measure precisely, direct comparisons of analyses are presented in scatter plots (**Figures 3-10** to **3-12**). Gross beta activity measurements have relatively small uncertainty terms, but there is also significant temporal variation in gross beta concentrations due to varying meteorological conditions.

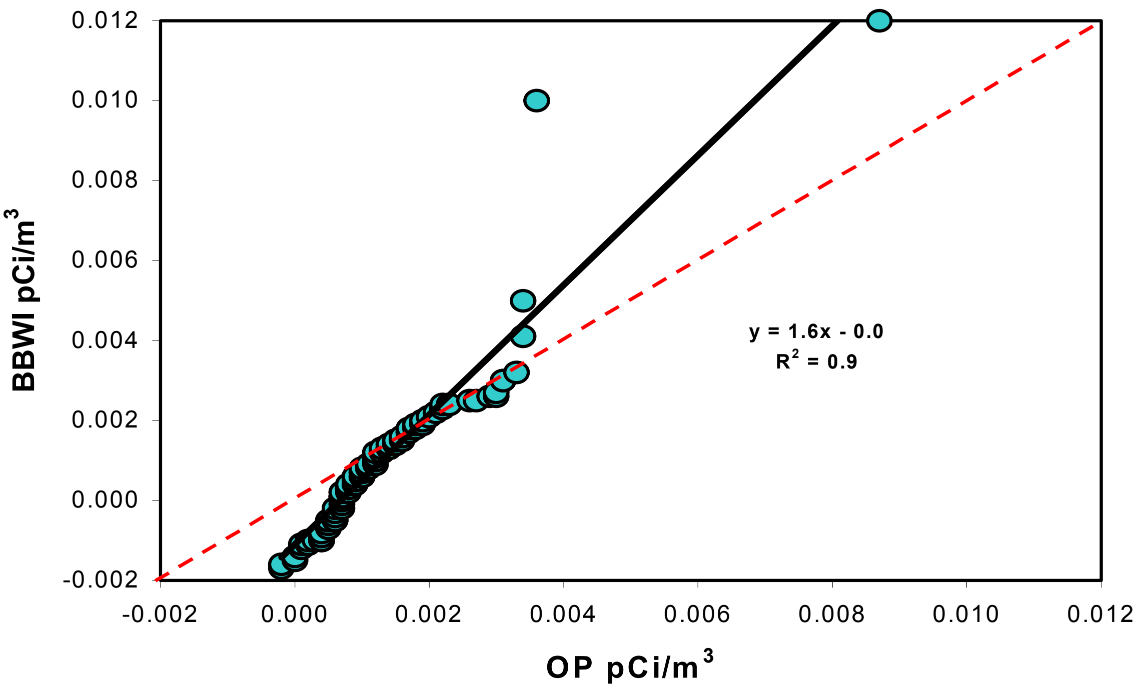

Figure 3-4. Quantile-quantile plot comparing INEEL OP and BBWI gross alpha concentrations in particulate air samples. The ideal regression is shown as a dotted line.

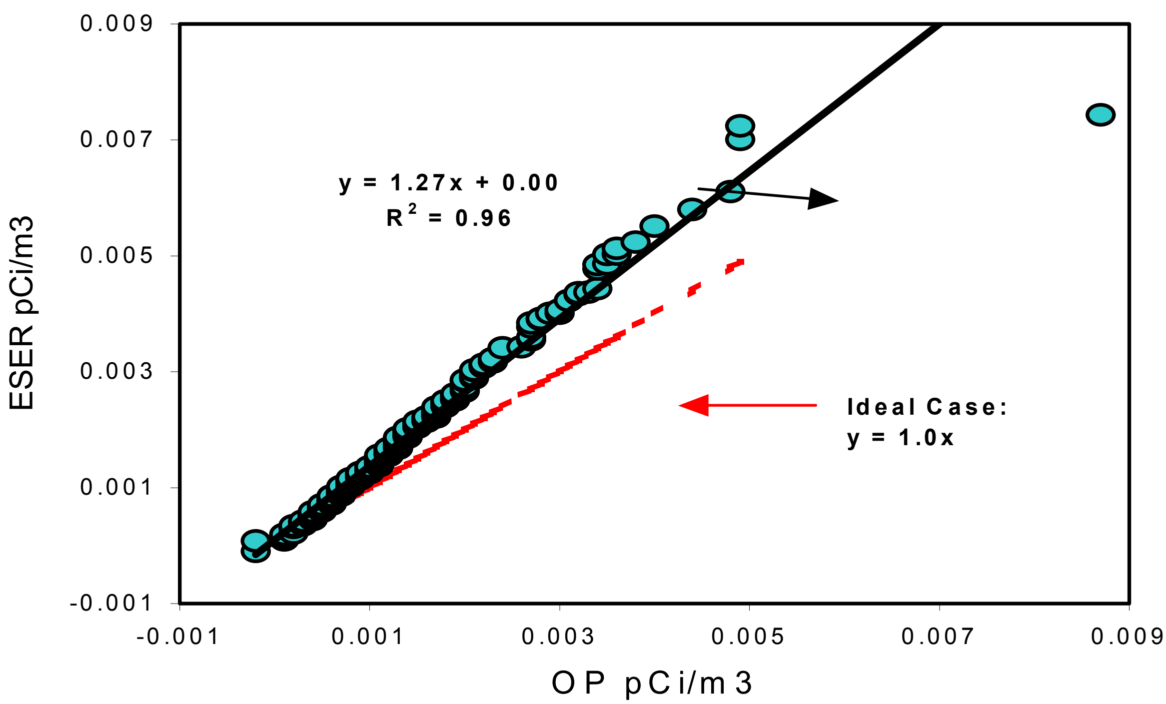

Figure 3-5. Quantile-quantile plot comparing gross alpha measurements of particulate air filters collected by ESER and INEEL OP in 2000. The ideal regression is shown as a dotted line.

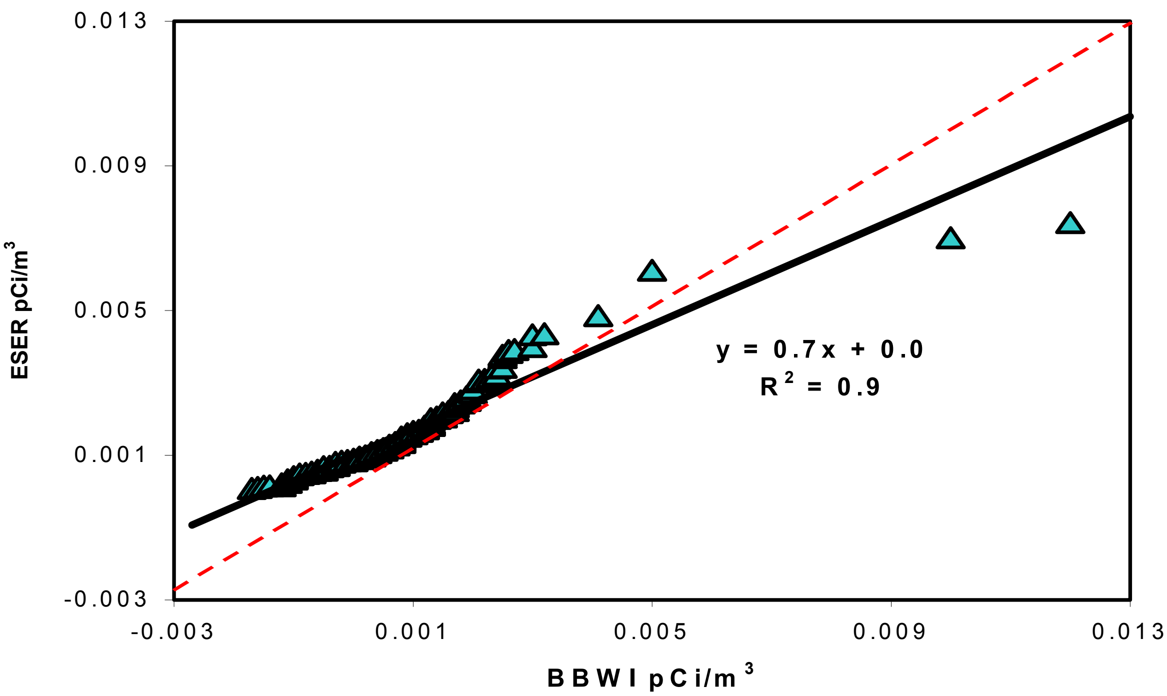

Figure 3-6. Quantile-quantile plot comparing ESER and BBWI gross alpha concentrations in particulate air samples collected at co-located monitoring locations during 2000. The ideal regression is shown as a dotted line.

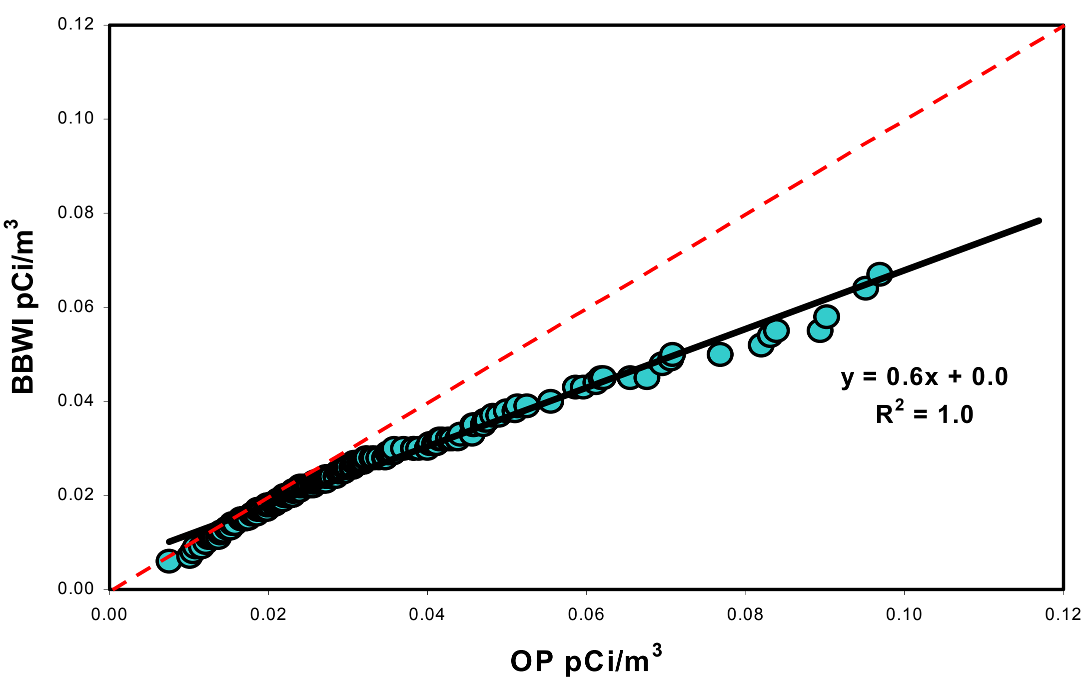

Figure 3-7. Quantile-quantile plot comparing INEEL OP and BBWI gross beta concentrations in particulate air samples collected at co-located monitoring locations during 2000. The ideal regression is shown as a dotted line.

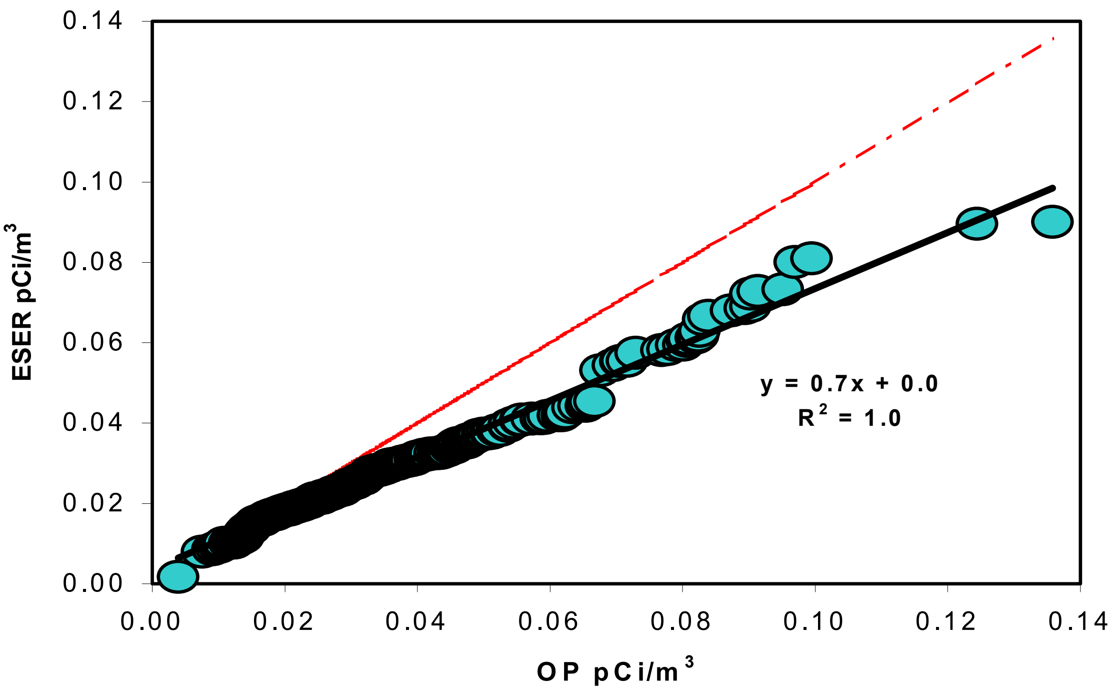

Figure 3-8. Quantile-quantile plot comparing INEEL OP and ESER gross beta concentrations in particulate air samples. The ideal regression is shown as a dotted line.

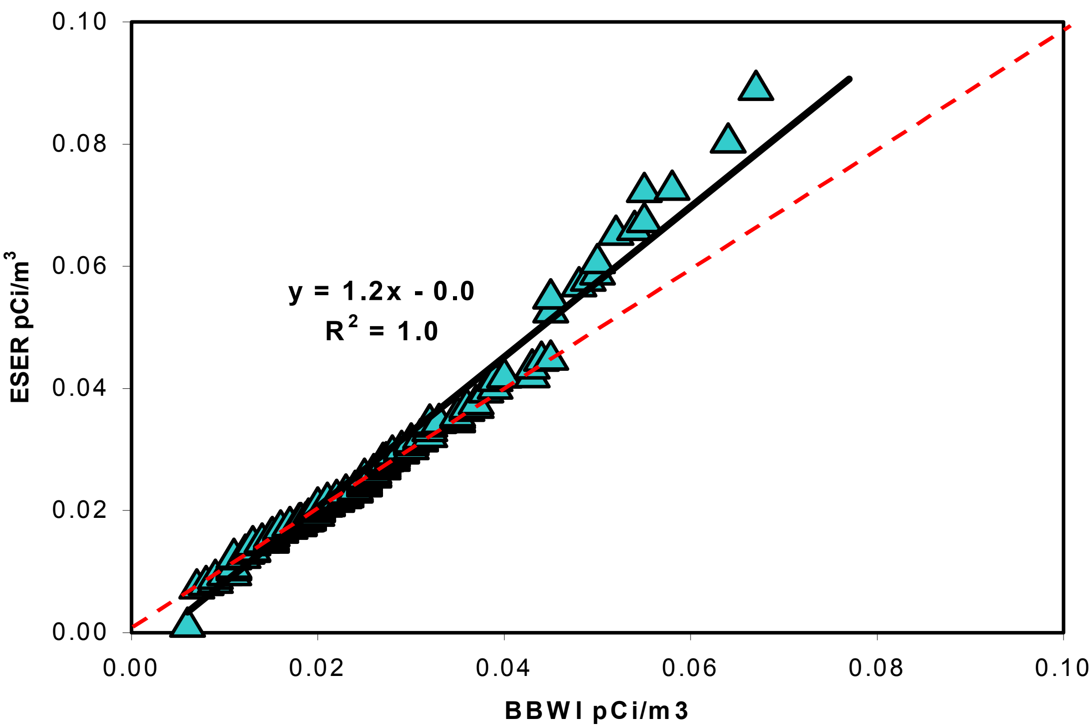

Figure 3-9. Quantile-quantile plot comparing ESER and BBWI gross beta concentrations in particulate air samples collected at co-located monitoring locations during 2000. The ideal regression is shown as a dotted line.

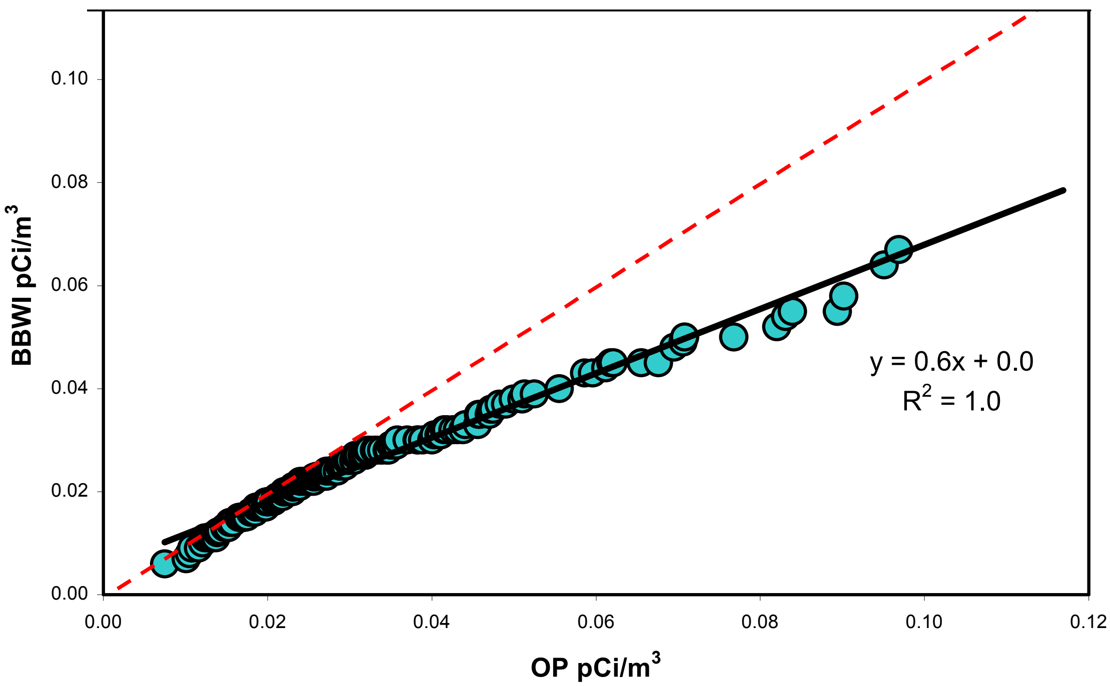

Figure 3-10. Scatter plot comparing ESER and INEEL OP gross beta concentrations in particulate air samples collected at co-located monitoring locations during 2000. The ideal is shown as a dotted line.

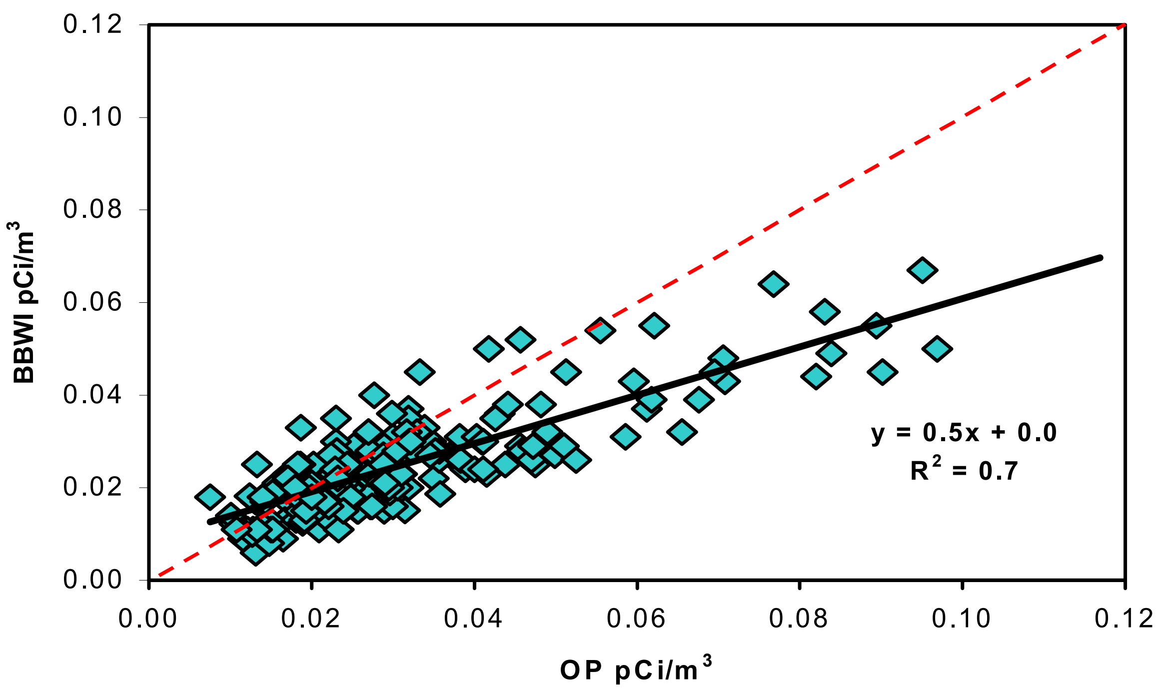

Figure 3-11. Scatter plot comparing BBWI and INEEL OP gross beta concentrations in particulate air samples collected at co-located monitoring locations during 2000. The ideal regression is shown as a dotted line.

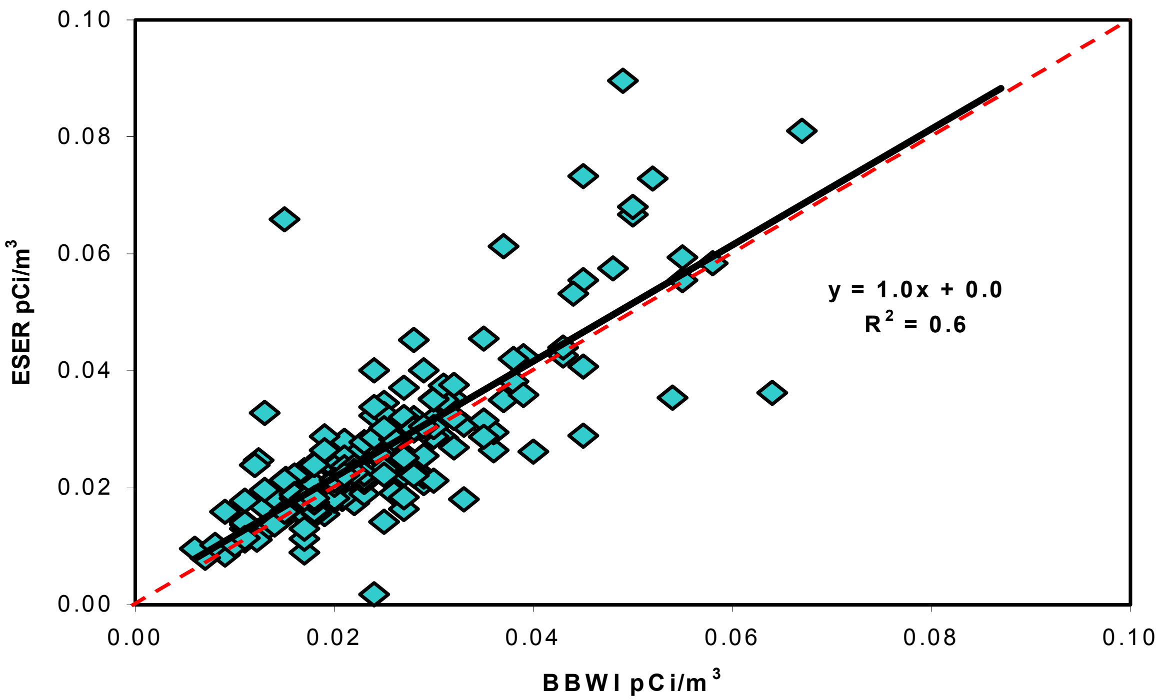

Figure 3-12. Scatter plot comparing gross beta measurements of particulate air filters collected by ESER and BBWI in 2000. The ideal regression is shown as a dotted line.

Environmental Tritium Comparison

Several differences exist as to how BBWI, ESER, and INEEL OP monitor tritium in the environment. These include sampling schedules, adsorbents used for collecting atmospheric moisture, and laboratory detection capabilities.

The comparison between INEEL OP and ESER involved tritium concentrations in atmospheric moisture samples collected at Atomic City and Idaho Falls. Descriptive statistics are shown in **Table 3-3**. The likely cause for the discrepancy between INEEL OP and ESER measurements is differences in laboratory detection capabilities, especially given the extremely small concentrations involved (nCi/L).

INEEL OP and BBWI atmospheric tritium concentrations (pCi/m^3) were compared for Craters of the Moon National Monument, Experimental Field Station, Van Buren Avenue, and Idaho Falls. Descriptive statistics are shown in **Table 3-4**. Atmospheric tritium concentrations observed compared well with a single BBWI outlier. Observed tritium concentrations were well below the INEEL OP action level of 790 pCi/m^3.

Table 3-3. Descriptive statistics for tritium concentrations in atmospheric moisture samples collected at co-located monitoring sites by INEEL OP and ESER

	INEEL OP	ESER
Average Concentration:	0.03 nCi/L	0.06 nCi/L
Median Concentration:	0.03 nCi/L	0.07 nCi/L
Standard Deviation:	0.03 nCi/L	0.11 nCi/L
Range:	-0.04 to 0.07 nCi/L	-0.16 to 0.26 nCi/L
Number of Samples Collected:	19	9

Table 3-4. Descriptive statistics for atmospheric tritium concentrations reported by INEEL OP and BBWI at co-located monitoring sites

	INEEL OP	BBWI
Average Concentration:	0.36 pCi/m^3	0.57 pCi/m^3
Median Concentration:	0.15 pCi/m^3	-0.18 pCi/m^3
Standard Deviation:	0.46 pCi/m^3	3.00 pCi/m^3
Range:	0.03 to 1.53 pCi/m^3	-1.35 to 17.40 pCi/m^3
Number of Samples Collected:	16	37

A comparison was made between tritium concentrations (nCi/L) observed by INEEL OP and ESER in precipitation samples collected in Idaho Falls during 2000. Descriptive statistics are shown in **Table 3-5**.

Table 3-5. Descriptive statistics for tritium concentrations in precipitation samples collected at a co-located monitoring site by INEEL OP and ESER

	INEEL OP	ESER
Average Concentration:	0.01 nCi/L	-0.01 nCi/L
Median Concentration:	0.01 nCi/L	0.02 nCi/L
Standard Deviation:	0.03 nCi/L	0.08 nCi/L
Range:	-0.04 to 0.04 nCi/L	-0.16 to 0.07 nCi/L
Number of Samples Collected:	4	12

Chapter 4
Terrestrial Monitoring

Major Findings and Developments

Gamma spectroscopic analysis of soil samples and milk samples collected during 2000 were consistent with historical concentrations. INEEL OP observed no man-made radionuclides in milk samples collected during 2000, specifically Iodine-131. Cesium-137 concentrations observed in soil samples collected during 2000 were consistent with historical measurements and with expected background concentrations attributable to historical atmospheric nuclear weapons testing.

- No off-site environmental impacts resulting from INEEL operations were indicated as a result of the analyses of milk or soil samples.
- Comparisons of gamma spectroscopic analysis of milk samples collected by DOE-ID contractor and INEEL OP indicated slight, yet expected, discrepancies likely due to differences in analytical techniques employed by the respective laboratories.

Primary Terrestrial Results and Trends

Terrestrial samples collected during 2000 found no evidence of INEEL radionuclide concentrations above levels considered to pose a health risk. Terrestrial monitoring involves collecting milk from distribution centers and soil samples at varying depths and locations. Milk and soil samples are analyzed via gamma spectroscopy specifically to identify man-made radionuclides.

Milk Sampling

Milk samples are collected monthly from milk distributors. Milk samples are analyzed for radioactive iodine, I-131. The MDC for I-131 in milk is 4 pCi/L, and milk samples are analyzed with gamma spectroscopy techniques involving close examination of the gamma spectrum produced in the 364 keV region of interest. **Figure 4-1** shows the reported concentrations of I-131 in milk samples collected by INEEL OP. INEEL OP has not observed I-131 concentrations greater than the MDC of 4 pCi/L since January 1996.

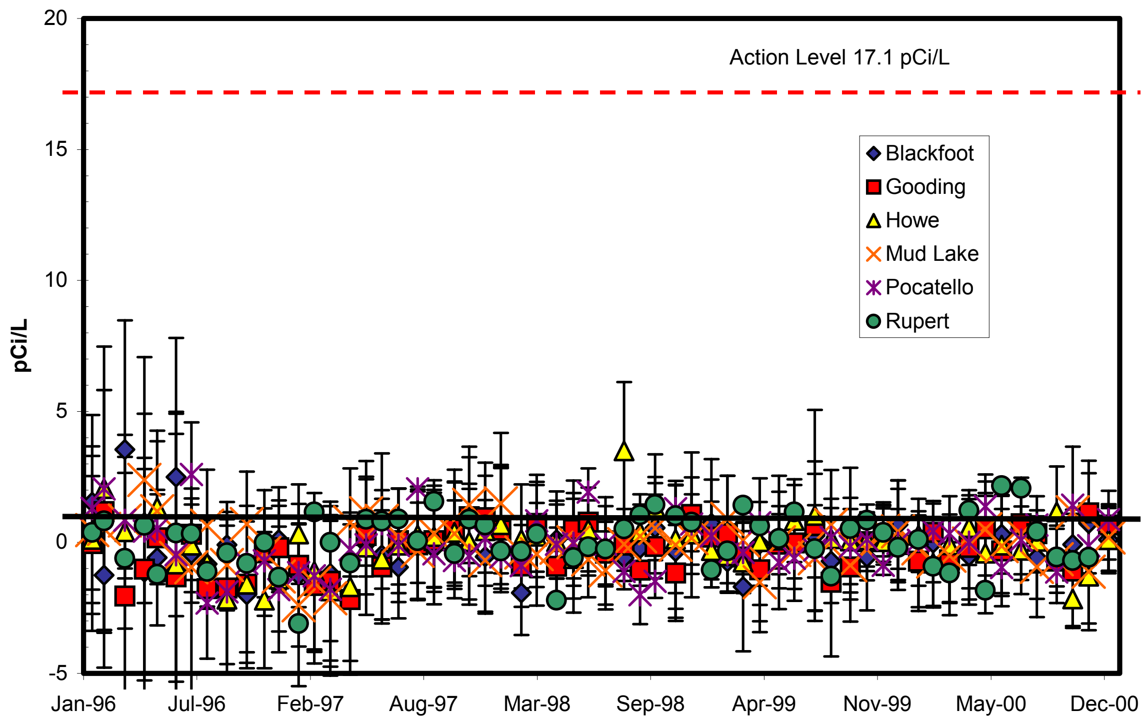

Figure 4-1. Concentrations of I-131 in milk samples collected monthly since January 1996. Concentrations of I-131 have consistently been less than the laboratory a priori MDC of 4.0 pCi/L. Error bars represent the 2-sigma counting uncertainty. The action level is shown as a dotted line.

Soil Sampling

Soil samples are collected from undisturbed locations near radiation monitoring stations at the surface (0-5 cm depth) and shallow subsurface (5-10 cm depth). Soil samples are collected in a manner that minimizes surface organic matter included in the sample and also minimizes cross-contamination of the sample.

Samples are submitted to ISU-EML for analysis. Samples are dried and sieved to remove rocks and then analyzed via gamma spectroscopy. Samples were collected at nine locations during 2000, including five on-site locations and four boundary locations. No discernible trends were observed when data collected during 2000 was compared with historical soil sampling data (**Figures 4-2** and **4-3**).

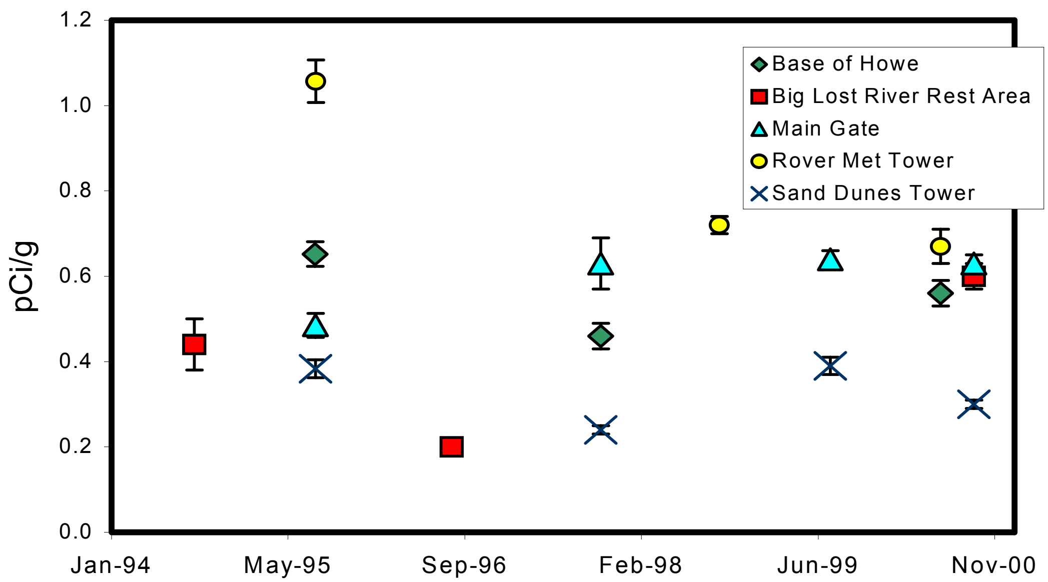

Figure 4-2. Cesium-137 concentrations in soil samples collected at on-site locations by INEEL OP during 2000. Plot represents soil samples collected from surface soils (0 - 5 cm). Error bars represent the 2-sigma counting uncertainty associated with the analytical measurement.

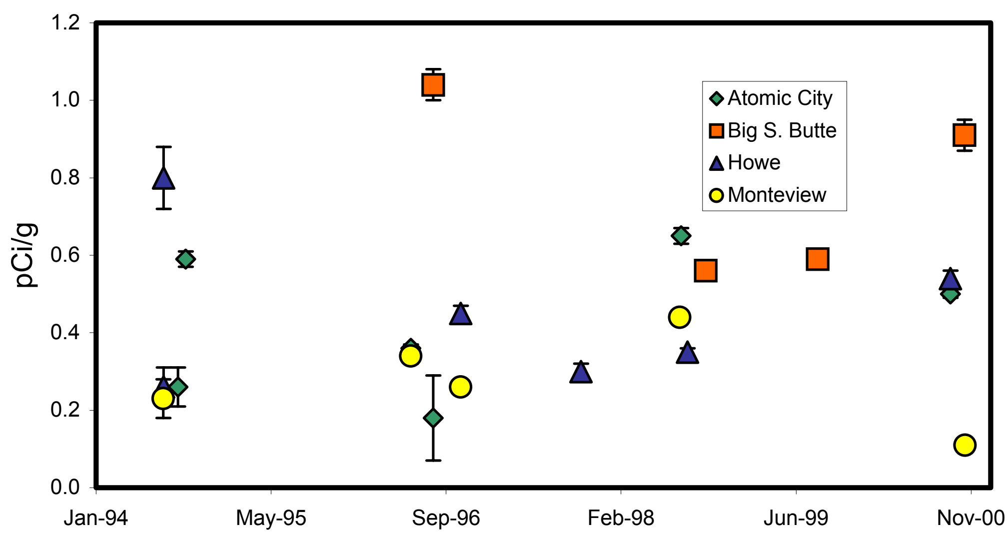

Figure 4-3. Cesium-137 concentrations in soil samples collected at boundary locations by INEEL OP during 2000. Plot represents soil samples collected from surface soils (0 - 5 cm). Error bars represent the 2-sigma counting uncertainty associated with the analytical measurement.

Interprogram Comparisons of Terrestrial Monitoring Results

Soil Sampling

During 2000, the INEEL OP did not co-sample soil with BBWI or ESER.

Milk Sampling

The INEEL OP and ESER programs perform gamma spectroscopic analyses of milk samples collected from dairies near the INEEL and from dairies located at distant locations with respect to INEEL. Neither INEEL OP nor ESER observed I-131 in 2000 milk samples.

Due to the lack of co-located sampling opportunities, agency differences in detection levels, and potential biases resulting from potentially different peak analysis algorithms used in gamma spectroscopy software, direct comparisons of INEEL OP and ESER I-131 and K-40 concentrations were not performed. The quantile-quantile plots shown in **Figure 4-4** and **Figure 4-5** demonstrate the excellent qualitative agreement between INEEL OP and ESER I-131 and K-40 concentrations. The good correlation coefficient (R^2 approaching unity, 1.0) indicates that the samples were collected from the same sample population. The slope indicates a bias likely due to the different background subtraction algorithms used by the different laboratories.

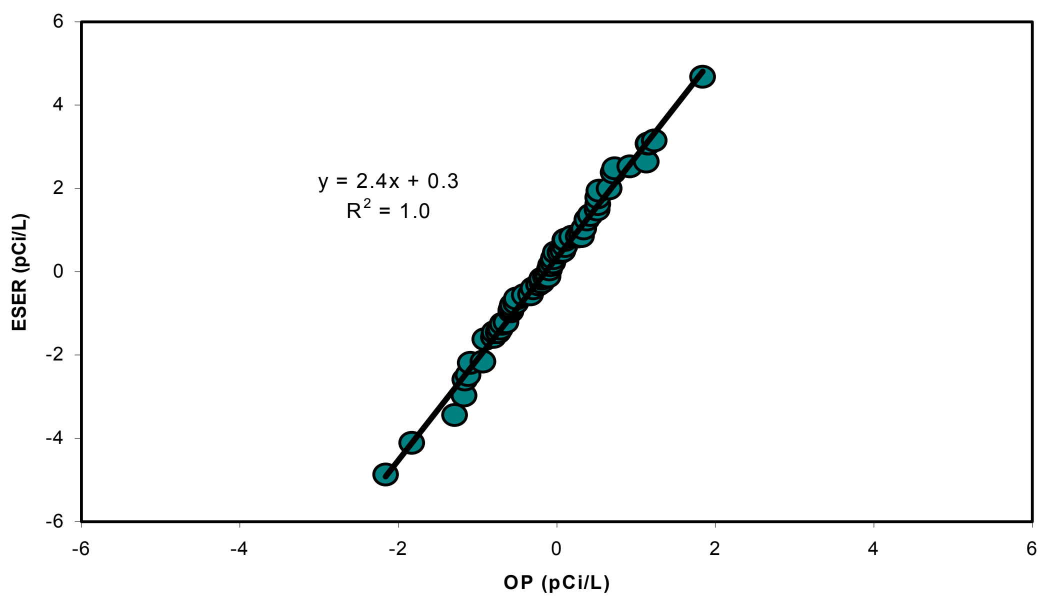

Figure 4-4. Quantile-Quantile plot comparing I-131 analysis results reported by ESER and INEEL OP from milk distributors. The relatively large slope indicates an analytical bias likely due to different background subtraction algorithms used by the different laboratories.

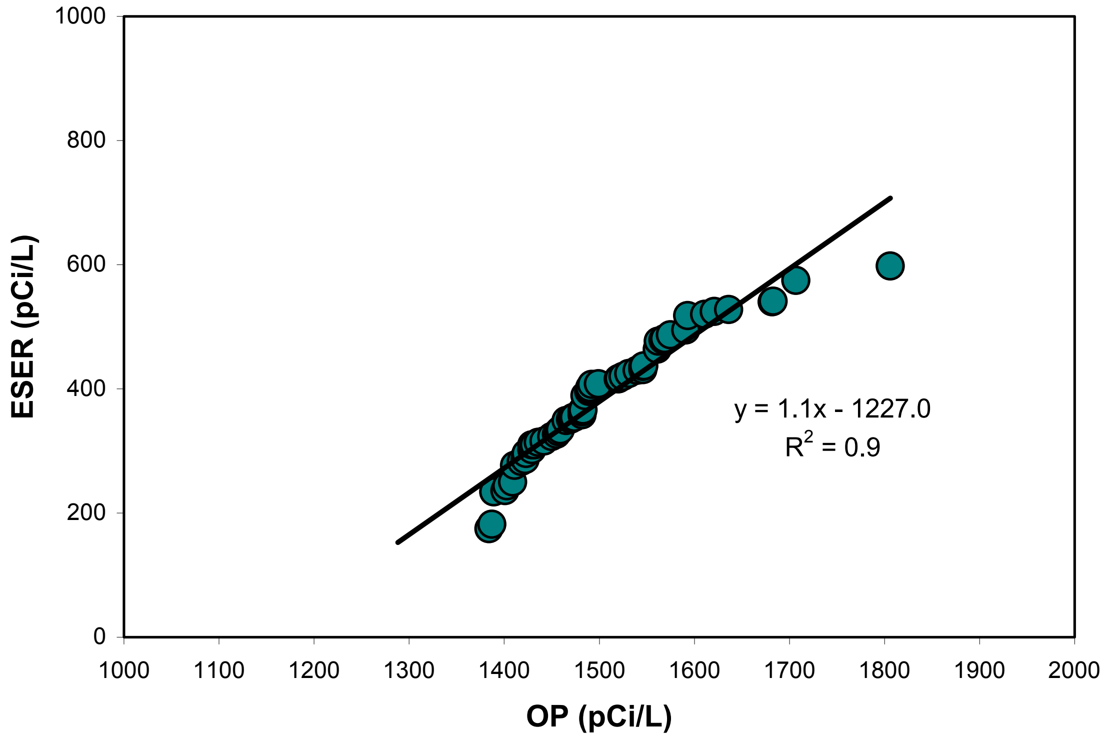

Figure 4-5. Quantile-Quantile plot comparing naturally occurring K-40 concentrations reported by ESER and INEEL OP milk samples. The relatively large y-intercept is due to a simulated milk background comprised of potassium chloride solution for background subtract algorithms used by the laboratory performing gamma spectroscopic analysis for ESER. The laboratory performing gamma spectroscopic analysis for INEEL OP uses a de-ionized water sample for background subtract.

References

United States Nuclear Regulatory Commission. *Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating compliance with 10CFR50, Appendix I.* Rev. 1. Washington: GPO, 1977.

Chapter 5
Water Monitoring

Major Findings and Developments:

Tritium, gross beta radioactivity, strontium-90, and chromium exceeded drinking water standards in the Eastern Snake River Plain Aquifer beneath several facilities at the INEEL. Contaminant concentrations generally decreased or remained constant through 2000.

- Drinking water standards were not exceeded at any sites where water is used by the public or INEEL workers.

- While no contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley monitoring sites, INEEL impacts can be identified at some sites along the southern boundary of the INEEL. Tritium at these sites was greater than expected background, but less than 1% of drinking water standard. Chromium at these wells exceeded background, but was less than 5% of the drinking water standard.

- Plutonium-239, 239/240 was detected above drinking water standards in one sample near the RWMC SDA.

- Analytical results from INEEL OP monitoring were generally in close agreement with results reported by the USGS and ESER.

Primary Nonradiological Results and Trends

Water samples collected by the INEEL OP in 2000 from distant or Magic Valley locations did not exhibit concentrations of nonradiological contaminants indicative of impacts from the INEEL. Similarly, the majority of analyses on samples collected from boundary wells detected only concentrations reflecting background or possible agricultural influences. However, common ions, nutrients, or trace metals attributable to INEEL impacts were detected in some boundary wells, as well as in several on-site wells. **Table 5-1** compares the minimum and maximum concentrations of the detected nonradiological constituents to their respective background estimations and any existing drinking water standards.

Water monitoring generates a considerable body of data requiring different depths of explanation. This section will focus on specifics regarding contamination from past or present INEEL activities. INEEL OP detected calcium, sodium, potassium, chloride, sulfate, nitrate plus nitrite, total phosphorous, barium, chromium, zinc, gross beta radioactivity, and tritium above background concentrations at some sites on the INEEL. Strontium-90 and technetium-99 are beta-emitting radionuclides disposed of to the aquifer and detectable in at least two INEEL OP on-site locations. A brief summary of these analytes is presented here. A more complete discussion of surveillance monitoring results for 2000 and historic trends for selected nonradiological and radiological analytes is presented in "Environmental Surveillance Program Water Quality Trends for Surveillance Monitoring Sties, 1994 - 2000 data" (Hall, 2002).

A synopsis of the sampling locations, schedules, analyses, and procedures specific to the INEEL OP water monitoring strategy appears in **Chapter 2.**

Table 5-1. Summary of nonradiological constituents detected in groundwater at levels believed to be related to waste disposal activities at the INEEL, 2000

Analyte	Range of Concentrations				Background[a] Concentrations for the Snake River Plain Aquifer	Drinking Water Standard
	Sites on the INEEL		Boundary, Distant and Surface water sites			
	Min Max	Median	Min Max	Median		
Common Ions/Nutrients (mg/L)						
Calcium	24.4 – 90.6	45.2	9 – 56.9	40.4	5 – 43	None[b]
Magnesium	11.8 – 27.6	16.3	2.8 – 19.9	14.8	1 – 15	None
Sodium	7 - 69	15	5.4 - 37	13	5 – 14	Proposed MCL[c] = 100
Potassium	1.1 – 6	3.2	1.1 – 6.6	2.8	1 – 3	None
Chloride	6.7 - 157	18.7	3.4 – 41.7	10.2	2 – 16	SMCL[d]=250
Sulfate	17.2 - 166	28.6	8.1 –57.9	22.1	2 – 24	SMCL=250
Total Nitrate plus Nitrite (as nitrogen)	0.389 – 4.14	0.912	0.008 – 1.93	0.761	1-2	MCL=10
Total Phosphorus	0.006 – 0.028	0.015	0.008 – 0.039	0.014	<0.02	None
Trace Metals (µg/L)						
Barium	27 - 233	49	17- 116	36.5	50 – 70	MCL=2000
Chromium	2-155	9	2 - 7	3	2 – 3	MCL=100
Zinc	2- 620	45	2 - 336	61	<10	SMCL=2000
Lead	<5 – 16	<5	<5	<5	<5	AL[e] = 15

a. Background is defined as ambient conditions for sites with no obviously anthropogenic influence. The range given is from Knobel and others (1992), or defined by the minimum and median from Knobel and others (1999).
b. Not applicable, no standard set.
c. Maximum Contaminant Level
d. Secondary Maximum Contaminant Level
e. Action Level

Common Ions and Nutrients

Calcium, magnesium, sodium, potassium, chloride, sulfate, total nitrate plus nitrite, and total phosphorus were detected in some groundwater samples collected on the INEEL at concentrations believed to represent contamination from activities on the site. Review of historical trends suggests a relationship between concentrations of these analytes at specific sample sites on the INEEL. These ions constitute a majority of the dissolved components of natural ground waters. These vary due to differences in geology of the aquifer recharge areas (Hall, 2000). Concentrations of these ions can also be elevated due to anthropogenic influences such as evaporation of infiltrating irrigation water.

Calcium

Calcium concentrations at several on-site wells (CFA 1, CFA 2, USGS 65, USGS 85, and USGS 112) exceeded expected background range for the aquifer estimated from data published by Knobel and others (1999). The highest concentrations are observed in samples from USGS 65. Calcium is not identified as a major component of INEEL wastewater. However, the elevated concentration and similarity in historical trends of calcium to other major wastes components such as sulfate suggest that the calcium values observed are disposal related.

Calcium concentrations in samples collected at Alpheus Spring exceeded the expected background. Concentrations of other analytes are slightly elevated at this site indicating possible anthropogenic influences.

Magnesium

Magnesium concentrations in samples from on-site wells exceed the expected background range for on-site wells CFA 1, CFA 2, USGS 65, and USGS 112, with CFA 2 having the highest concentrations. Magnesium and calcium results follow similar trends for CFA 1 and CFA 2, and for USGS 65 and USGS 112. Magnesium is a natural constituent of ground water beneath the INEEL. Yet, magnesium is not identified as major INEEL waste constituent. Therefore, it is difficult to determine if the observed concentrations represent INEEL impacts. Trends observed with INEEL wells with known impacts indicate that observed concentrations are elevated due to waste disposal at INEEL facilities.

Magnesium concentrations observed from boundary and distant well samples generally were below the estimated background. Concentrations of magnesium in samples from Mud Lake Water Supply averaged significantly lower than all other sites due to natural variability within the Snake River Plain aquifer.

Sodium

Although no EPA established or proposed drinking water standard exists for sodium, 100 mg/L has been proposed as a standard (Salvato, 1992). Sodium is identified as a major waste constituent for INEEL facilities. Concentrations for wells CFA 1, CFA 2, USGS 85, and USGS 112 reflect that waste disposal influence. The highest concentrations are observed in well USGS 112, and historical trends follow patterns similar to chloride and to most other major ions for CFA 1 and CFA 2. Historically chloride concentrations for USGS 112 have fluctuated, and declined since about 1997. Concentrations of sodium for USGS 120 have been increasing since 1997 possibly due to the recharge from the Big Lost River spreading areas south of the RWMC and USGS 120.

In general, the boundary, distant, and surface water samples yielded sodium concentrations within background levels due to local natural aquifer variability. Concentrations for Mud Lake water supply exceed the published background range. Due to natural aquifer variability, concentrations for USGS 27 and Alpheus Spring might be reflective of either natural variability or local anthropogenic influences.

Potassium

Drinking water standards have not been established for potassium. Concentrations of dissolved potassium in groundwater samples collected are typically less than 4 mg/L. These vary as a result of geologic conditions, waste disposal at the INEEL, or anthropogenic influences.

Potassium concentrations from on-site wells USGS 112, CFA 1, and CFA 2 show trends similar to sodium at these locations. While not significantly greater than the expected background levels, some of the potassium present is due to past disposal activities at INTEC. Apparent correlation between sodium and potassium concentration trends is apparent for USGS 120. The highest potassium concentrations observed were for samples from upgradient well USGS 27 inside the INEEL boundary near Mud Lake.

The potassium concentration was highest at Alpheus Spring for boundary, distant and surface water sites. The Mud Lake Water Supply well, near USGS 27, had potassium concentrations slightly above the background range with no indication of anthropogenic influences. Potassium concentrations observed for USGS 27 may represent local ambient concentrations or local anthropogenic influences.

Chloride

The secondary maximum contaminant level (SMCL) for chloride is 250 mg/L, historically a major constituent of INEEL chemical wastes. Elevated chloride may indicate surface water, irrigation, or other anthropogenic impacts.

Chloride concentrations for onsite wells USGS 112, 115, 85, CFA 1, and CFA 2 exceeded the background range, with the highest values found in samples from USGS 112 (nearly 4-5 times the next highest concentrations observed at USGS 115). Since 1997, chloride concentrations for USGS 112 have dropped by about one third. Trends for CFA 1 and CFA 2 reflect those for other analytes. Concentrations for other INEEL sites are near the upper background range. Chloride levels are likely impacted by waste disposal for these sites, including USGS 65.

Alpheus, Clear Springs, and Minidoka water supply exceeded the background range. Other constituents suggest that Alpheus and Clear Springs have some degree of impact due to anthropogenic sources not associated with the INEEL. Minidoka water supply chloride concentrations are likely due to natural sources with no indication of impact from INEEL activities or other manmade sources.

Sulfate

No wells sampled exceeded the SMCL of 250 mg/L for sulfate, historically a major INEEL waste constituent. Elevated sulfate can also be an indication of impacts from surface water, irrigation, or other anthropogenic impacts.

Sulfate concentrations were highest in samples collected from USGS 65, where water quality has been impacted by waste disposal at TRA. Concentrations for wells USGS 112, 85, 87, 120, 104, CFA 1, CFA 2, and RWMC Production all exceed the background range for sulfate. Trends for sulfate are similar to calcium and magnesium. Concentrations for USGS 120 have increased from 1997 through the end of 1999, and appear to be declining through 2000. Concentrations for these wells are likely due to INEEL waste disposal, with exception of USGS 120, possibly being impacted by the recharge event at the nearby Big Lost River spreading area.

Alpheus, and Clear Springs sulfate concentrations were highest for boundary, distant and surface water samples. These sulfate results along with chloride concentrations are attributable to a combination of local anthropogenic influences.

Total Nitrate Plus Nitrite As Nitrogen

The MCL for nitrate plus nitrite (as nitrogen) is 10 mg/L with concentrations greater than 1-2 mg/L indicating anthropogenic impacts to groundwater of the Eastern Snake River Plain Aquifer. (Rupert 94, Rupert 97)

Nitrogen concentrations are elevated for seven onsite locations, and greatest for wells CFA 1, CFA 2, and USGS 112. Elevated concentrations at these and other sites (USGS 65, 85, 115, and 100) are the result of past wastewater disposal at INTEC and TRA. The highest concentration detected in groundwater is from well CFA 2. The upgradient site USGS 27 likely shows agricultural impacts.

Concentrations for boundary, distant, and surface water sites were all within the 1-2 mg/L background range. Alpheus Springs, already discussed as having concentrations of other constituents indicative of anthropogenic impacts, was near the upper background range.

Total Phosphorus

Identified as waste constituents for INEEL facilities, total phosphorous exceeded the background levels in two wells, USGS 112 and USGS 85. The median result for sample sites on the INEEL was similar to distant, boundary and surface water sites.

While the median phosphorus result for boundary, distant, and surface water sites ranged less than the onsite locations, the highest values were from a boundary location, Mud Lake water supply. This higher concentration is indicative of local hydrogeologic conditions because other indicators of anthropogenic influences are absent at this well (low nitrate + nitrite and very low tritium).

Trace Metals

Groundwater samples collected by INEEL OP in 2000 were analyzed for barium, chromium, zinc, lead, and manganese. Chromium and barium can be directly linked to INEEL waste disposal activities. Concentrations of zinc, lead, and manganese were also detected. These measurements may be related to well construction materials, natural concentrations in the environment, as well as to activities at the INEEL.

Barium

In all 2000 water samples, barium concentrations were considerably lower than the MCL of 2000 μg/L. Barium was detected in all samples collected from INEEL sites, with the highest concentrations being reported for USGS 112. Barium was above background levels for CFA 1, CFA 2, and USGS 85. Barium has historically been a waste product from INTEC. Historical trends reflect those of other known INEEL waste constituents (e.g., sodium and chloride). Concentrations for upgradient sites USGS 19 and USGS 27 reflect regional concentrations.

Barium concentrations for boundary, distant, and surface water sites were highest for samples collected from the Big Lost River and lowest for sites on the eastern side of the INEEL. The distribution for sites not influenced by the INEEL may provide information on recharge areas for ground water.

Chromium

The primary source of chromium contamination at the INEEL is the TRA, where it was used as a corrosion inhibitor until 1972. Lesser amounts of chromium, used for the same purpose, were disposed of at INTEC. Chromium concentrations for samples from USGS 65, located south of TRA exceeded the MCL of 100 μg/L.

Samples for other INEEL sites; RWMC Production, USGS 85, 87, CFA 1, CFA 2, and USGS 115 exceed background. Other sites, USGS 104, 103, 108, 112, and 14 also show results greater than background. Monitoring results suggest the chromium background in the vicinity of the INEEL may be greater than the published range of 2-3 μg/L. Chromium in excess of about 6-7 μg/L for samples from onsite locations downgradient from TRA-INTEC is likely due to historical waste.

Chromium for boundary, distant, and surface water sites were less than 7 μg/L with a median of 4.5 μg/L. All surface water and distant sites were at or less than the detection level. Concentrations for boundary sites USGS 14, 103, 104, 108, 124, and 125 may indicate INEEL impacts, contamination from well materials, or natural fluctuations in background.

Zinc, Lead and Manganese

There does not appear to be a clear relationship between a disposal point, distribution within the aquifer, and historical contaminant trends for remaining trace metals.

Zinc concentrations were less than the secondary MCL (2000 μg/L) with highest zinc concentrations observed in samples from USGS 115. Other INEEL wells with elevated zinc include USGS 65 and 112. Elevated zinc was observed at wells USGS 103 and Highway 3. These two wells do not show an INEEL impact based on other indicators. CFA 1 and CFA 2, which are clearly impacted by other INEEL waste disposal constituents do not have detectable zinc. Wells with detectable zinc all have dedicated submersible pumps installed in them. Many of the sites that do not have detectable zinc or have very low zinc have turbine pumps or are surface water sites. Thus, some degree of zinc contamination may be related to the well construction and pumping.

Historically, lead and manganese have been measured in some INEEL waste streams and detected in a limited number of INEEL monitoring wells. Lead was detected in samples from two wells on the INEEL. Manganese was detected at eight sites. Seven of these eight sites were boundary or distant sample locations, with one located near a facility. Manganese concentrations ranged from the detection level to 5 μg/L onsite and 36 μg/L for one boundary location. While both of these contaminants are or have been present in INEEL waste waters, concentrations are within that reported by others for the Eastern Snake River Plain Aquifer (Wood and Low, 1988) and are likely due to conditions local to the well or natural variability and not INEEL impacts.

Primary Radiological Results and Trends

Water samples were collected by the INEEL OP for gross alpha and gross beta radioactivity, gamma spectroscopy, and tritium. Samples from selected sites were also collected for strontium-90 and technetium-99. Table 5-2 summarizes INEEL OP's radiological results for water sampling.

A synopsis of the sampling locations, schedules, analyses, and procedures specific to the INEEL OP Water Monitoring strategy appears in **Chapter 2**.

Table 5-2. Summary of radiological constituents detected in groundwater at concentrations believed to be related to waste disposal activities at the INEEL, 2000

Analyte	Range of Concentrations (pCi/L)						Background Concentration for the Snake River Plain Aquifer	Drinking Water Standard
	Sites on the INEEL			Boundary, Distant and Surface water sites				
	Min	Max	Median	Min	Max	Median		
Gross Alpha (as Thorium–230)[a]	1.4 pCi/L	4.6 ± 3.5	<MDC	2.5	5.1 ± 1.9	2.5	0 – 3	15
Gross Beta (as Cesium-137)[a]	2.5 pCi/L	48 ± 2	2.35 ± 0.8	1.4	4.8 ± 0.9	1.6 ± 0.8	0 – 7	50[b]
Cesium-137[c]	<MDC	2.9 ± 2.1	<MDC	<MDC	<MDC	<MDC	0	[b]
Tritium[c]		14760 ± 260	1270 ± 110	<MDC	150 ± 90	<MDC	0 – 40	20,000
Tritium[c,d]	<MDC	101 ± 8	16 ± 6	<MDC	169 ± 9	16 ± 6	0 – 40	20,000
Strontium-90	3-4 pCi/L	17 ± 2	5.3 ± 1.9	N/A			0	8
Technetium-99	2-3 pCi/L	77.6 ± 2.5	1.2 ± 2.0	N/A			0	[b]

a. The terms “as thorium-230” and “as cesium-137” refer to the radionuclide used to calibrate the instrument and do not imply that the activities present are due to the presence of these specific radionucides.
b. Expressed as a cumulative annual dose of 4 millirem/year. For unspeciated gross beta, 50 pCi/L is used as an action level; for cesium-137, 4 millirem is equivalent to 200 pCi/L, if cesium-137 were the only detectable radionuclide.
c. MDC for cesium is typically >6 pCi/L, for tritium by standard analysis methods MDC is 160 pCi/L and for tritium by enhancement method MDC is 10-15 pCi/L.
d Tritium analyzed using an Electrolytic Enhancement Method. For onsite locations, this includes just those samples that did not exceed MDC for tritium by the standard method.

Gross Radioactivity

Water samples collected from all sample sites are analyzed for gross alpha and gross beta activity. Gross measurements are a screening tool used to identify whether or not more specific analyses are needed.

Gross Alpha Radioactivity

Samples from 12 locations visited during 2000 returned results for gross alpha radioactivity exceeding the MDC (approximately 2.5 pCi/L) but well below the MCL of 15 pCi/L.

Three onsite locations yielded samples with detectable gross alpha, with all detections very near the MDC. USGS 120 yielded detections during the first two quarters of the year, including the maximum value observed, 4.6 ± 2.6 pCi/L. No gross alpha radioactivity trends are apparent for any monitored sites, and sites with gross alpha detections in 2000 are sites where other INEEL contaminants are not detected. Thus, onsite gross alpha detections are attributable to naturally occurring radionuclides (uranium and thorium isotopes). Nine boundary, distant, and surface water sites yielded detections also.

Gross alpha radioactivity levels for all sites were within the range expected for naturally occurring radioactivity due to uranium and thorium decay products in the aquifer and illustrate the range of activity typical for the Eastern Snake River Plain.

Gross Beta Radioactivity

Samples from 50 of 55 locations visited during 2000 returned results for gross beta radioactivity exceeding the MDC of approximately 1.4 pCi/L. Drinking water MCLs are based on an exposure limit equivalent to 4 millirem per year to the whole body.

Gross beta radioactivity concentrations for samples collected from on-site wells ranged from less than the MDC to 49.7 " 1.9 pCi/L. The highest observed gross beta activities were from samples from observation wells USGS 85 and USGS 112, where groundwater is known to have been impacted by historical waste disposal practices at INTEC. Gross beta concentrations for these sites has been in general decline over the entire period of monitoring (1993-2000), but has fluctuated for the last few sampling quarters. Gross beta radioactivity trends, along with trends for strontium-90, for sites USGS 85 and 112 are presented in **Figure 5-4** later in this chapter.

Gross beta radioactivity concentrations in samples collected from the boundary, distant, and surface water sites ranged from less than the MDC to 7.4 " 1.2 pCi/L. While ambient concentrations for gross beta radioactivity across the Eastern Snake River Plain Aquifer can vary considerably, typical values range from less than the MDC to about 7 pCi/L.

Gamma Spectroscopy

Gamma spectroscopy results are reported for cesium-137, potassium-40, and for any other identified gamma-emitter. No cesium-137 results exceeded the MDC. In 2000, 11 samples from 10 sites yielded detections for naturally occurring potassium-40. Approximately 0.01% of all potassium naturally consists of radioactive potassium-40. Background potassium-40 concentrations for the aquifer are approximately 0 – 7 pCi/L, significantly less than the detection level for this isotope (100 – 130 pCi/L). This isotope is the predominant radioactive component in normal foods and human tissues (Eisenbud and Gesell, 1997). No other gamma-emitting radionuclides were identified.

Tritium

Tritium concentrations for onsite monitoring locations did not exceed the MCL of 20,000 pCi/L for any sample collected in 2000. Concentrations in onsite samples for 2000 ranged from less than the MDC to 14,760 " 260 pCi/L . Nine onsite wells yielded tritium concentrations above the approximately 160 pCi/L MDC for all samples collected during 2000. The highest tritium values are from USGS 65. The other onsite locations with detectable tritium are USGS 112, 85, 115, CFA 1, CFA 2, RWMC Production, USGS 87 and 104.

One sample from boundary, distant, and surface water sites exceeded the MDC, USGS 124. Background levels of tritium in the Snake River Plain Aquifer range from 0 to 40 pCi/L.

Onsite wells with detectable tritium were downgradient from TRA-INTEC and are known to have been impacted by historical waste disposal at those facilities. Tritium concentrations for most of these wells continued to decrease through 2000. Wells USGS 65, 112, and 115 near INTEC decreased 10% or more from 1999 levels. Historical trends for these locations are presented in **Figure 5-1.**

As seen in **Figure 5-2**, tritium concentrations in USGS 85 have a similar downward trend. Concentrations at CFA 1 and CFA 2 have fluctuated, but generally decreased by about 5% in the last year. Monitoring at the RWMC production well and at USGS 87 and USGS 104 suggests relatively constant tritium concentrations, as shown in **Figure 5-3.**

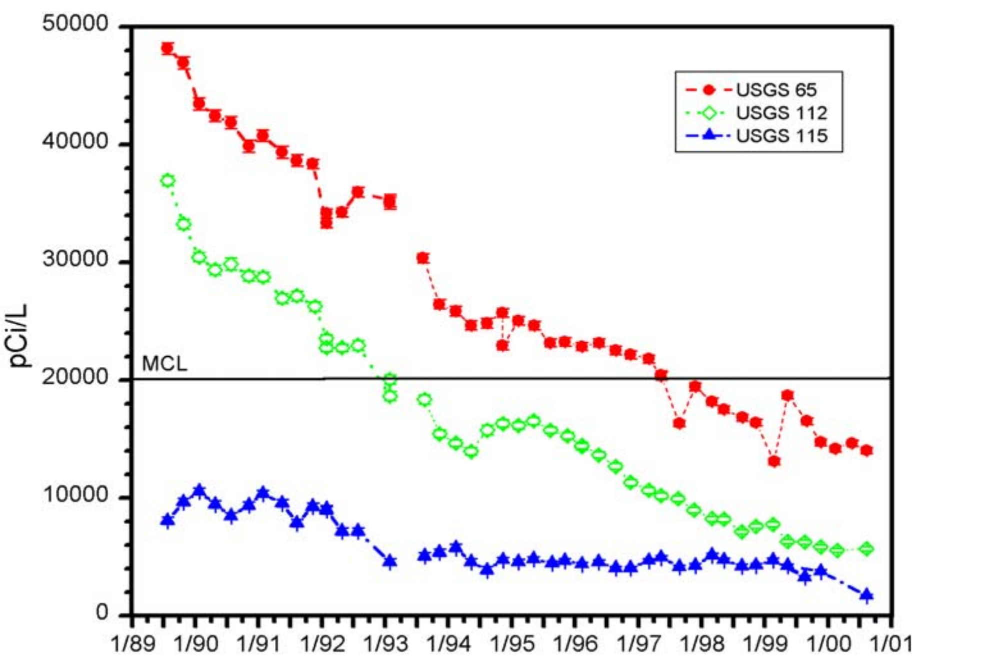

Figure 5-1. Tritium concentration over time, wells USGS 65, 112, and 115. Error bars are analytical uncertainty at 2 sigma.

An electrolytic enhancement technique was used to reanalyze samples that did not yield detectable tritium using the standard liquid scintillation analysis method. The MDC for standard tritium anlyses is about 160 pCi/L and about 10-15 pCi/L for enriched tritium analyses.

Onsite locations reanalyzed using the enhanced tritium method ranged from less than the MDC to 101 " 8 pCi/L. Samples from seven onsite locations were reanalyzed. Results from two locations, USGS 120 and Highway 3 were above expected ambient concentrations, with an average of 76 ± 7 pCi/L and 66 ± 8 pCi/L for samples from these sites. The remaining sites, P&W 2, Site 14, USGS 19, and USGS 27, showed concentrations indicating some degree of recent recharge, but low enough that INEEL impacts are not suspected.

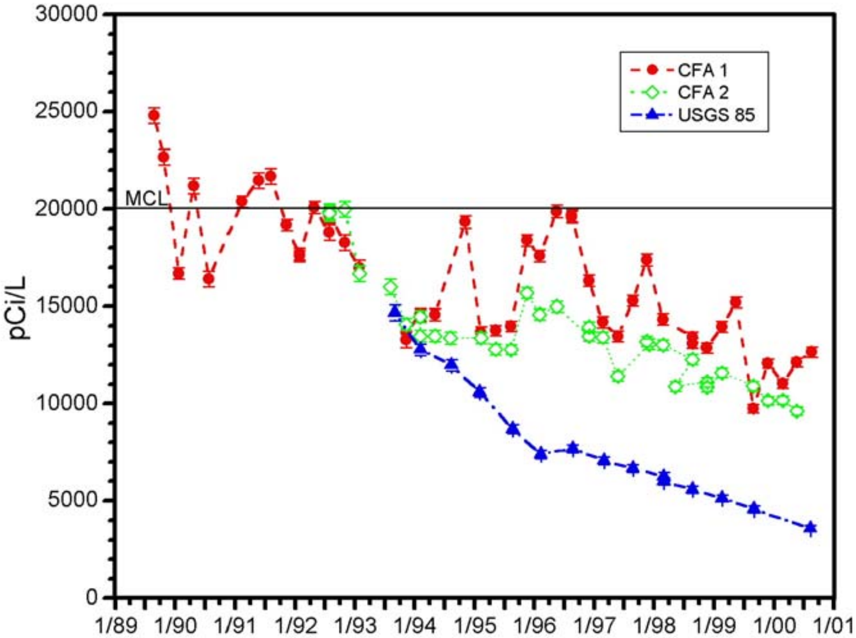

Figure 5-2. Tritium concentration over time, wells CFA 1, CFA 2, and USGS 85. Error bars represent 2-sigma uncertainty.

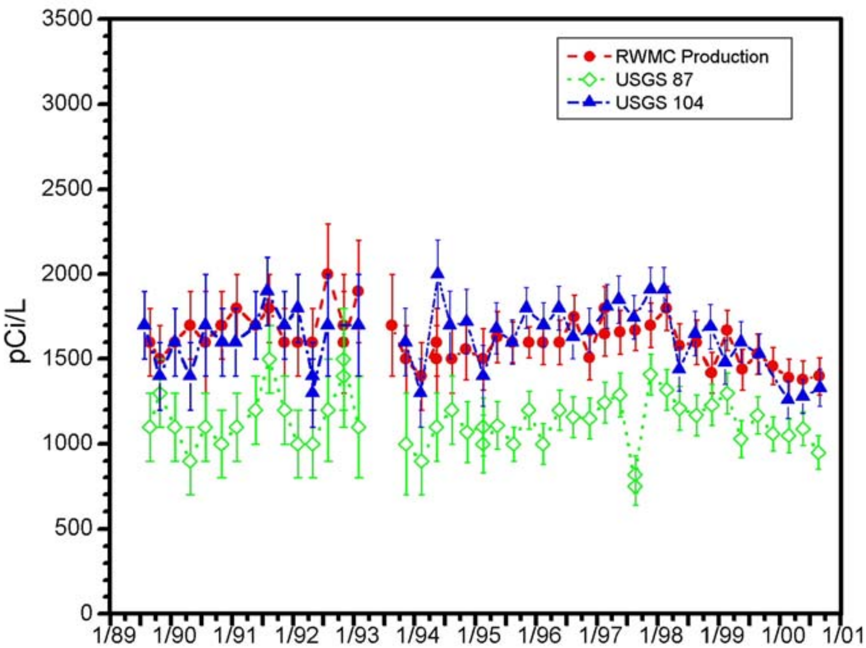

Figure 5-3. Tritium concentration over time, wells RWMC Production, USGS 87 and 104. Error bars represent 2-sigma uncertainty

Enhanced tritium analysis of boundary sites indicate some degree of INEEL tritium contamination for some sites. Concentrations ranged from less than the MDC to 196 " 9 pCi/L. Tritium samples from USGS 11, 14, 108, 124, and 125 were greater than expected for ambient conditions. Concentrations for these sites ranged from the 15 " 6 pCi/L at USGS 14 to 196 " 9 pCi/L at USGS 124. Historical sampling at USGS 11 and 14 have revealed contaminants, chlorine-36 and iodine-129. Although tritium concentrations at this site are less than those observed at other boundary locations, the presence of these contaminants suggest that the tritium at this site is from INEEL waste disposal. Tritium concentrations for USGS 8 average about 40 " 6 pCi/L, consistent with concentrations observed for Big Lost River sites, and other sites that are influenced by surface waters or irrigation.

Low-level tritium results for distant sites Alpheus Spring and Shoshone water supply average 38 " 6 pCi/L and also show nitrate values 1.2 to 1.9 mg/L, indicative of some degree of influence by surface water and irrigation. Tritium results for Clear Spring average about 11 " 6 pCi/L with nitrate concentrations greater than 1 mg/L, indicating lesser influence by isotopically young surface water (Rupert and others, 1997) and irrigation.

Rupart (1997) suggested that where tritium concentrations exceeded about 4.5 pCi/L, some portion of that groundwater had been recharged since the advent of nuclear testing in the early 1950s. Differing degrees of mixing older and recent (post-1950's) water result in the range of natural tritium concentrations observed. Groundwater in the central portion of the Eastern Snake River Plain Aquifer where sources of recent recharge are absent or minimal, the tritium concentrations should be less than the ISU-EML MDC for enhanced tritium analysis.

Strontium-90

Samples from four onsite wells were analyzed for strontium-90. At CFA 1 and CFA 2, strontium-90 was below the MDC. In wells USGS 85 and USGS 112, strontium-90 appeared to be the predominant source of gross beta radioactivity, with a concentration of 3.1 " 0.03 pCi/L and from 13 " 1 to 17 " 2 pCi/L, respectively.

Strontium-90 concentrations with the gross beta radioactivity are shown in **Figure 5-4**. Assuming that strontium-90 is in equilibrium with yttrium-90 , the counting instrument will see two beta decays each time one strontium-90 decay occurs. If strontium-90 is the most significant beta-emitter, there should be approximately a two-to-one ratio between gross beta radioactivity and the strontium-90 concentration. **Figure 5-4** appears to confirm the two-to-one relationship between gross beta radioactivity and strontium-90, and suggests that in these two wells strontium-90 is the major source of gross beta radioactivity.

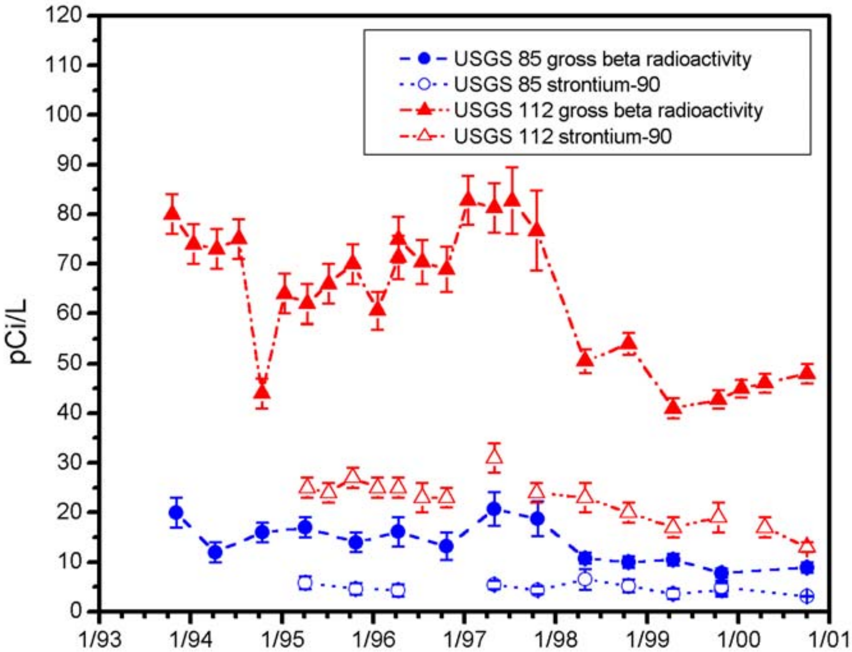

Figure 5-4. Comparison of gross beta radioactivity and strontium-90 concentrations in wells USGS 112 and 85.

Technetium-99

Technetium-99 is a fission product produced primarily in nuclear reactors, with a half-life of about 21,000 years, presumably introduced to the aquifer through the INTEC injection well and possibly through the TRA Warm Waste Ponds. This long half-life, coupled with the fact that technetium-99 does not occur naturally, makes this constituent useful as a tracer to evaluate groundwater movement through the aquifer.

Samples were collected from five locations with concentrations ranging from less than the MDC of about 2.5 pCi/L to 78 " 3 pCi/L. Concentrations are expected to decrease with distance from the injection zone along the axis of the strontium-90 contamination plume. The highest concentrations were measured in samples from well USGS 112 (24 " 3 to 78 " 3 pCi/L), with a concentration of 2.4 ± 2.1 for well USGS 85. Samples collected from wells CFA 1 and CFA 2 were –0.5 ± 1.7, 6.9 ± 3, and 1.4 ± 2.2 pCi/L.

During 2000, the ISU-EML conducted a special study to investigate use of ion-selective filter disks for analysis of technetium-99. Archived samples from USGS 112, 115, and 85, and samples collected from CFA 1, 2, and USGS 112 during 2000 were processed through the special media. Reasonably good agreement was seen between technetium-99 results from a contract laboratory, and from ISU-EML. The ISU-EML method provides a ten-fold increase in sensitivity (ISU-EML, 2000).

Plutonium

The INEEL OP co-sampled two groundwater sites near the SDA (M1S and M3S) of the RWMC as part of a special study, 1998-2000. The two sites were co-sampled with the DOE contractor (LIMITCO, until fall, 1999, and BBWI thereafter), and the USGS. These data were reported in the fourth quarter 2000 Environmental Surveillance Program (ESP) quarterly report.

Samples from well M1S yielded detectable concentrations of Pu 239/240 and Pu 238 for March 2000 (0.90 ± 0.34 and 0.81 ± 0.32 pCi/L), and October 2000 (0.36 ± 0.19 and 24 ± 2 pCi/L) samples.

A replicate sample for M1S, March 2000, failed to confirm the detection in the primary sample. The March replicate samples were collected within seconds of each other, and were handled and shipped for analysis in exactly the same manner. While the initial analysis for the October, 2000, sample from M1S yielded detections, reanalysis from the same sample container failed to return a detectable result. Additional quality assurance information requested from the analyzing laboratory failed to identify any reason to reject the 24 ±2 pCi/L Pu 239/240 result.

In addition to the requested reanalysis of this October 2000, sample, the remaining volume from the sample container was returned to ISU-EML and analyzed for gross alpha and gross beta radioactivity. This post-screening did not yield detectable gross alpha radioactivity (at a detection level of 2-3 pCi/L). Detailed review of the October analyses failed to identify any problems that would cause INEEL OP or the laboratory to reject the primary result for either Pu 238 and Pu 239/240. From this review, there are at least two possible conclusions for the primary plutonium isotope results (specifically the 24 ± 2 pCi/L Pu 239/240). One possibility is the Pu 238 and Pu 239/240 detected in the first 100 ml sub-sample were present in localized amounts in that first sub-sample and not the second. Another possibility is the sample or detector may have been contaminated. A more complete discussion of 1998 and 2000 results plutonium from wells M1S and M3S is published in Hall, 2002.

With the first quarter of 2001, M1S and M3S were included in regular INEEL OP Environmental Surveillance Program verification sampling, with a list of analytes that reflects the range of analytes sampled for by the contractor.

Interprogram Comparisons of Water Results

The INEEL OP collects samples concurrently with the USGS and ESER. Goals for the water sampling conducted by these three monitoring organizations differ, but similar analytical techniques serve to support meaningful interprogram data evaluation.

Comparisons of available 2000 monitoring results were made for various radiological parameters for all co-sampled locations. Nonradiological results were compared for locations co-sampled with the USGS on and near the INEEL. A detailed synopsis of the sampling locations, schedules, analyses, and procedures specific to interprogram comparisons appears in **Chapter 2**.

During 2000, replicate samples were collected with the USGS at 27 groundwater and surface water locations on and near the INEEL. In addition, the INEEL OP and the USGS collected replicate groundwater and surface water samples at 18 locations in the Magic Valley.
The INEEL OP and ESER co-sampled at three springs and two drinking water supply wells south of the INEEL and in the Magic Valley.

Linear regression analyses were applied to data where a sufficient number of replicate sample pairs were available. When such regressions were not meaningful, differences between replicate results were compared with histograms of the differences and evaluated with t-tests to compare population means. Relative percent differences are used for comparison when data are too limited for comparison by other means.

Nonradiological Results Comparisons

Linear Regression Comparisons

Samples collected by INEEL OP for nonradiological analyses are analyzed by the Idaho Bureau of Labs (IBL) in Boise and replicate samples from the USGS for nonradiological parameters are analyzed at the National Water Quality Laboratory (NWQL).

Regression results were meaningful for replicate data for chloride, chromium, nitrate plus nitrite (total Nitrogen), sodium, and sulfate. As summarized in **Table 5-3**, and depicted in **Figures 5-5** through **5-9**, linear regression comparisons of INEEL OP and USGS results showed excellent agreement for replicate data. Such agreement was not true for total phosphorus.

Table 5-3. Regression parameters with 95% confidence intervals for the replicate samples collected by the USGS and the INEEL OP, 2000.

Analyte	Slope	y-intercept	R	P	SD of the predicted value	Number of replicate sample sets
Chloride	1.00 " 0.006	0.10 " 0.29	0.999	$<10^{-4}$	1.81	64
Chromium	1.01 " 0.03	2.96 " 2.01	0.996	$<10^{-4}$	6.26	15
Nitrate + nitrite (as nitrogen)	0.98 " 0.01	-0.00 " 0.02	0.997	$<10^{-4}$	0.05	34
Total Phosphorus	0.65 " 0.11	0.00 " 0.00	0.787	$<10^{-4}$	0.002	24
Sodium	0.97 " 0.01	0.38 " 0.31	0.995	$<10^{-4}$	1.13	42
Sulfate	0.97 " 0.01	0.02 " 0.49	0.9996	$<10^{-4}$	1.35	17

Chloride

Sixty-four replicate sample sets were collected for chloride in 2000. Regression analyses showed good agreement (**Figure 5-5).** Because the USGS collects a filtered sample for dissolved chloride, while the OP collects an unfiltered sample for total chloride, this data agreement indicates the chloride present is largely in dissolved form.

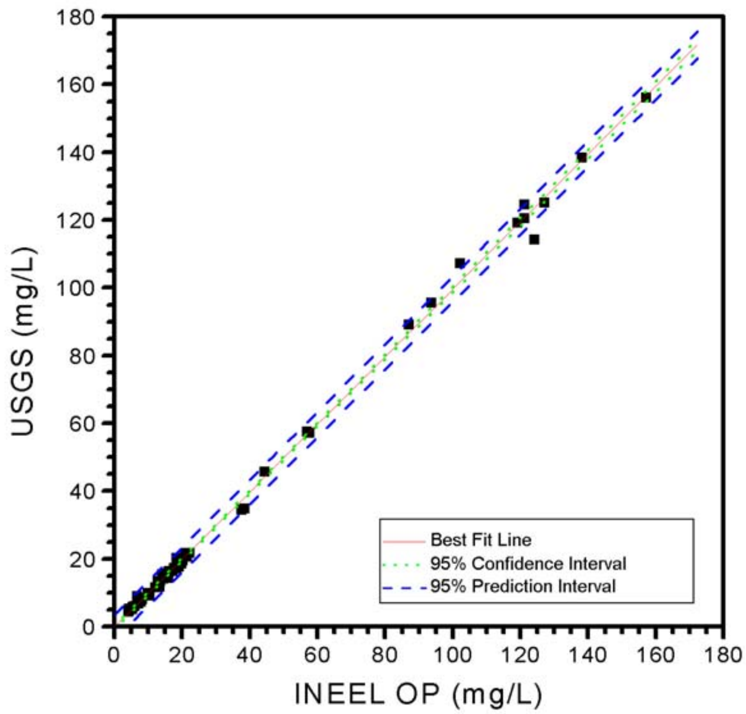

Figure 5-5. Concentrations of chloride reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2000.

Chromium

Thirty-four replicate dissolved chromium results were available for 2000. Ten results were less than the 2 Fg/L MDC for the INEEL OP, and another nine were also reported as less than the 10 - 14 Fg/L MDC for the analyzing laboratory used by the USGS. EPA guidance suggests that for replicate samples in which the concentrations are less than five times the MDC, results are comparable if they differ by less than the sample MDC. All 19 of these replicates differed by less than the sample MDC. In addition to these replicates, values were reported for five analyses that are less than the 10 Fg/L reporting level. These results are included in regression analysis.

Regression analyses, presented in **Figure 5-6**, showed excellent agreement with nearly identical results for the 15 replicate results detecting chromium in both samples. Although the number of replicate pairs is small, the regression is strong, as evidenced by the small uncertainty for the slope, the high correlation coefficient (R), and the very low p-value. The y-intercept for the regression does not bound zero, and has an uncertainty equal in magnitude. It is likely that this uncertainty reflects the difference between the reporting levels for the respective laboratories. The uncertainty is roughly equivalent to the lowest reporting level of the two laboratories.

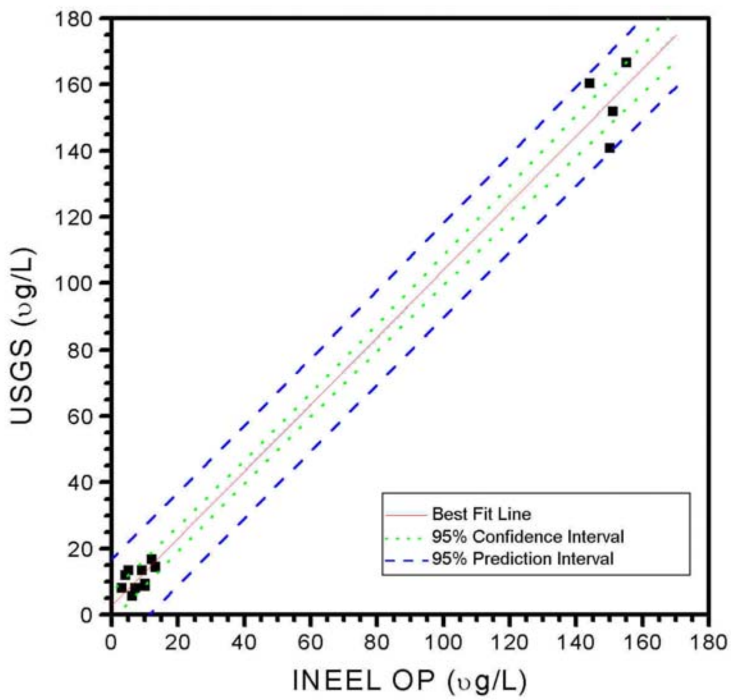

Figure 5-6. Concentrations of chromium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2000.

Nitrate plus Nitrite as Nitrogen and Total Phosphorus

Regression analysis for the 34 replicate results for total nitrate plus nitrite (as N) between INEEL OP and USGS results (**Figure 5-7A)** show excellent agreement. The slope suggests an imperceptible difference between USGS and INEEL OP results (slope of 0.98 and uncertainty of 0.01). The y-intercept for this regression is slightly less than zero.

Replicate analyses for total phosphorus were available for 34 sample pairs, with total phosphorus detected for both samples for 24 of these sample pairs. One result was less than the 0.005 mg/L MDC for the INEEL OP, and another ten were also reported as less than the 0.01 – 0.018 mg/L MDC for the analyzing laboratory used by the USGS.

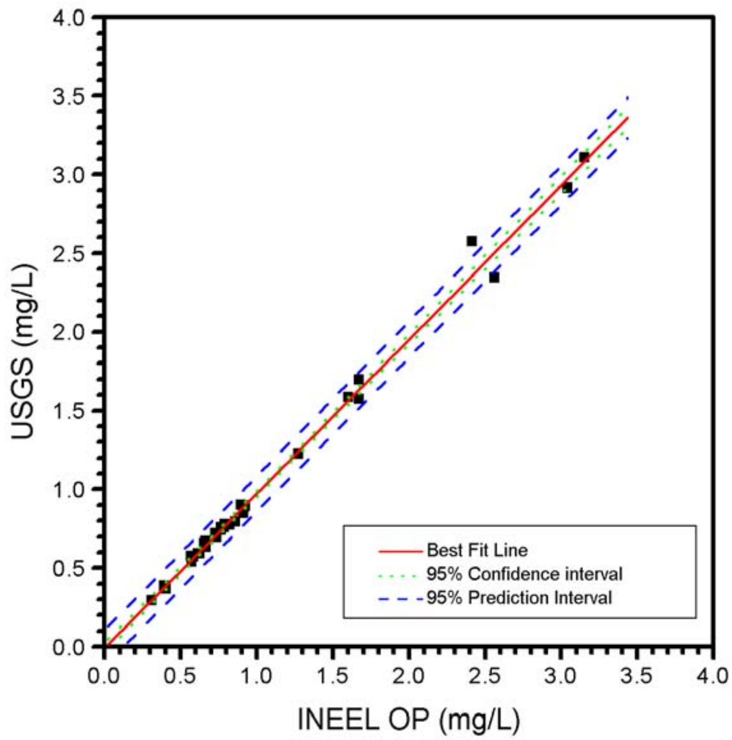

Figure 5-7A. Concentrations of dissolved nitrite plus nitrate (as N) reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2000.

Regression analysis of the 24 sample pairs, where both had detections, failed to yield a meaningful regression, based on the correlation coefficient (R) less then the given criteria of 0.8. However, the P-value and standard deviation associated with this regression are both small, suggesting that there may be an observable and predictable relationship. The regression analysis is presented in **Figure 5-7B**. The intercept value for the regression is very small, however, the associated slope departs from 1 significantly (0.65 ± 0.11).

Paired t-tests and analyses of differences were calculated for replicate total phosphorus results compared by regression. Paired t-test results for these data indicated that the means differed at the 95% confidence level, with a mean difference of 0.002 mg/L. The regression slope suggests that the INEEL OP sample result is usually greater, and the mean difference for the paired data concur. This regression is very weak compared to the other nonradiological analytes compared here because all the results are close to the least sensitive MDC (in this case, 0.01 – 0.018 mg/L for the USGS).

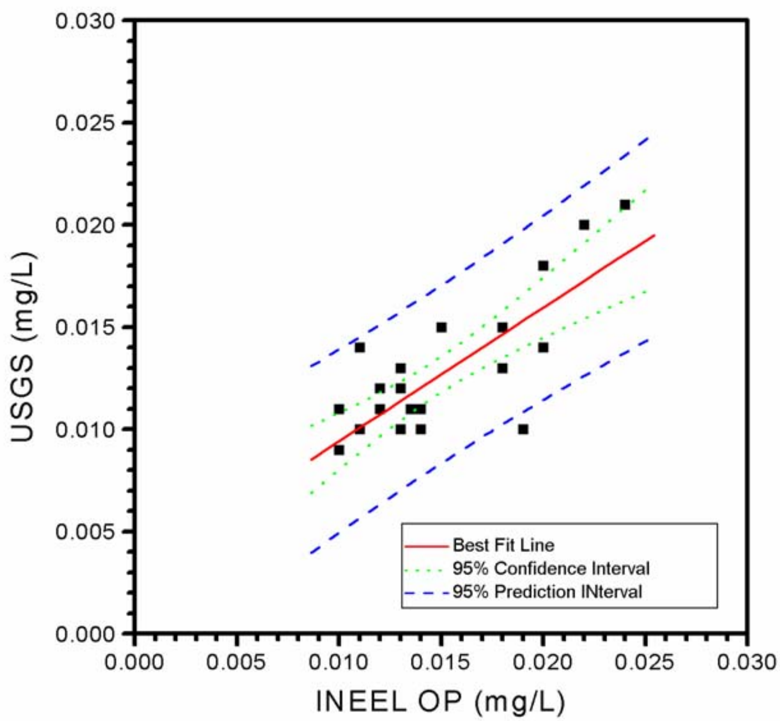

Figure 5-7B. Concentrations of dissolved total phosphorus reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2000

Sodium and Sulfate

There were 17 replicate results for sulfate and 42 replicate results for sodium. Sulfate results shown in **Figure 5-8** demonstrate good agreement, with a slope of 0.97 and a y-intercept that bounds zero. The regression analyses presented in **Figure 5-9** indicate that the sodium results are well-correlated with a slope of 0.97 and a y-intercept slightly greater than 0.

Comparisons for both sodium and sulfate analyses are relatively unchanged from the previous year. A slightly greater standard deviation for both sodium and sulfate regressions as compared to 1999 indicates slightly increased data variability.

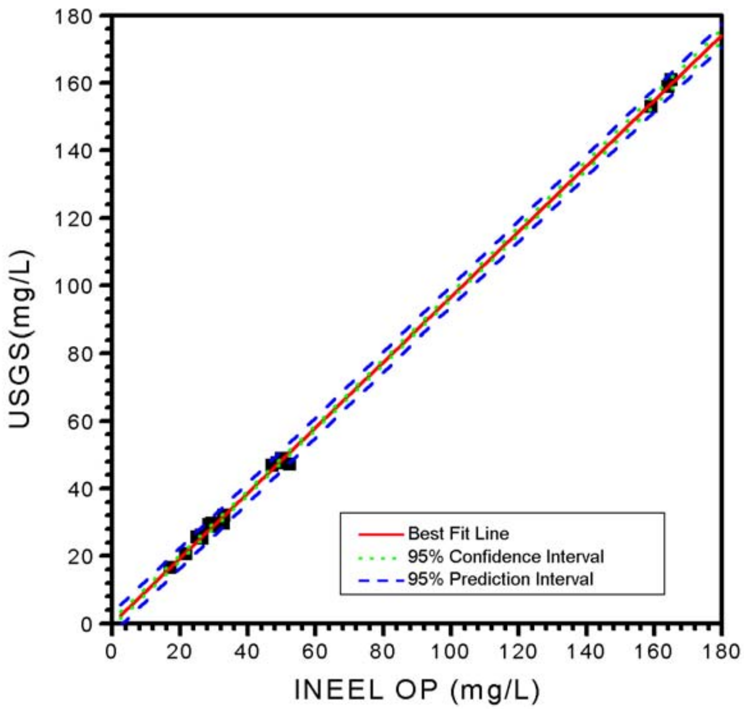

Figure 5-8. Concentrations of sulfate reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2000.

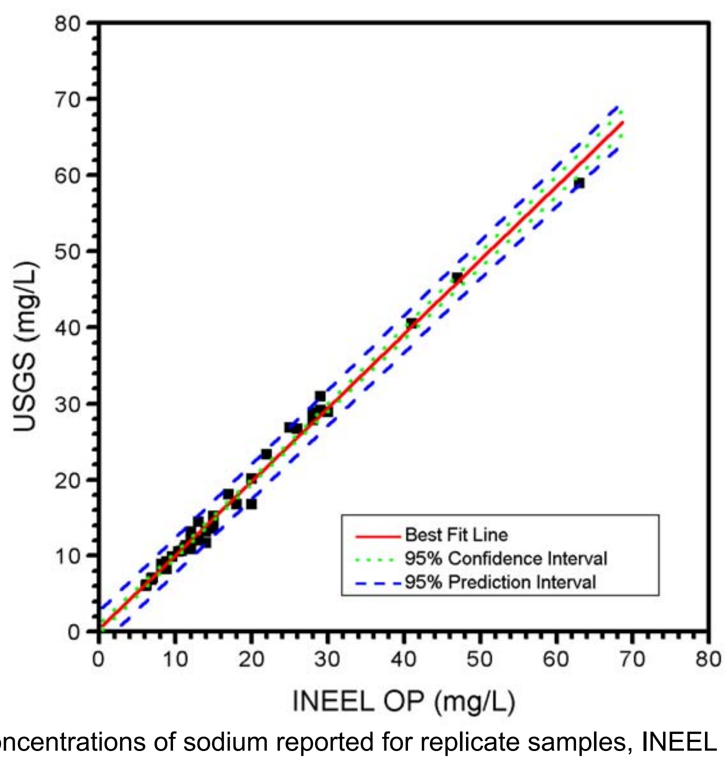

Figure 5-9. Concentrations of sodium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2000.

Relative Percent Differences Comparisons

Relative percent differences showed excellent agreement for all of the analytes that could not be compared with linear regressions. **Table 5-4** demonstrates the comparison of the concentrations of these constituents reported in replicate samples during 2000.

Table 5-4. Comparison of common ions, nutrients and trace metals concentrations reported for replicate samples, 2000.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference <20%, or where results are within +/- detection limit	Percent of replicate samples with comparable results
Barium	3	3	3	100
Chromium	34	15	19[a]	100
Chloride	64	64	(compared by linear regression)	
Lead	3	0	3	100
Manganese	3	0	3	100
Sodium	34	34	(compared by linear regression)	
Sulfate	17	17	(compared by linear regression)	
Total nitrite plus nitrate	34	34	(compared by linear regression)	
Total phosphorus as P	34	27	34[b]	100
Zinc	3	3	3	100

[a] Fifteen replicate pairs compared by linear regression.
[b] Linear regression was not meaningful.

Two replicate sample sets were collected for barium, lead, manganese, and zinc from USGS 65. A third set of results compared as replicate was from USGS 11. INEEL OP results compared for this well and specific analytes are actually from October 2000 sampling, while the USGS results are from July 2000.

The INEEL OP and the USGS both collected filtered samples for phosphorus during 2000. While the reporting level was exceeded for both samples in 25 of 32 replicate pairs, comparison by linear regression did not yield a good regression. Comparison by paired t-test concluded that the mean of all INEEL OP and all USGS results were significantly different (t-statistic of 4.4 and p-value of <0.002). All 34 replicate pairs for total phosphorous were within plus or minus two times the MDC of 0.01 mg/L for the USGS at the National Water Quality Laboratory (NWQL).

In summary, comparisons of INEEL OP and USGS results for nonradiological analytes demonstrate excellent agreement for nearly all replicate data. Such close agreement between results indicates that data between respective programs are comparable, and that there are no significant biases introduced by differences in sample collection or analysis methods for replicate samples collected during 2000.

Radiological Results Comparisons

Replicate sample results for gross alpha, gross beta, tritium and strontium-90 were available for samples collected by the INEEL OP and the USGS on and near the INEEL, and for the USGS Magic Valley sampling program, an area including sites from the southern boundary of the INEEL to the Snake River between Twin Falls and Hagerman. Replicate sample results are also available for the five locations INEEL OP co-samples with ESER in the Magic Valley.

Differences in the methodology used by an individual agency can influence inter-program comparisons, as radiological analyses are not presently standardized to the same level of detail as most nonradiological analytes. **Table 5-5** provides a synopsis of collection and analysis methods used by the INEEL OP, ESER, and the USGS, and summarizes their possible impacts on comparability of gross alpha and gross beta radioactivity results.

For each analyte, regression analysis was attempted first. If that regression was meaningful, a plot of the data was presented without further analysis. **Table 5-6** indicates the analyses that could be applied to each analyte.

When the regression results were not meaningful, the data were compared using a paired t-test to evaluate whether the means of the data were the same. **Table 5-7** summarizes these results. To characterize the differences between replicates, the result obtained by the INEEL OP was subtracted from ESER or USGS result. **Table 5-8** outlines these differences for each of the respective analytes.

Histograms of these differences were generated to identify outliers and illustrate how the differences are distributed. Superimposed is a normal curve fitted to the histogram. Where field replicates were collected by the INEEL OP, the mean of these replicates and the pooled analytical errors were compared to the replicate results from ESER and USGS.

Gross Alpha Radioactivity

A total of 60 replicate results for gross alpha radioactivity were available: 10 co-sampled with ESER, 30 with the USGS on and near the INEEL, and 20 with the USGS in the Magic Valley.

With regression results not meaningful, paired t-test analysis indicated that, at a 95% confidence level, the means of gross alpha radioactivity measurements made by the INEEL OP did not differ from those made by ESER, the USGS in the Magic Valley, or the USGS on the INEEL. Statistical comparison results are presented in **Tables 5-6, 5-7,** and **5-8**. Histograms of these differences are presented in **Figures 5-10, 5-11**, and **5-12**.

INEEL OP gross alpha radioactivity results tended to be less than all compared replicate results. Differences were small, typically less than the 2 sigma uncertainty for these measurements.

Table 5-5. Sampling and analysis techniques for gross alpha and gross beta samples collected by the INEEL OP, the USGS and ESER, 2000.

Sampling or analytical technique	INEEL OP	ESER	USGS-INEEL Monitoring Program	USGS-Magic Valley Monitoring Program	Effect on measured concentration
Manufacturer, model, and operational mode for gas-proportional counting system, and typical count time.	Protean 5", automatic feed, thin-window, 300 minutes.	Canberra 1.85" (47 mm), automatic feed, thin-window, 125 minutes.	For alpha, scintillation counter and 60 minutes. For beta, Tennelec 2", automatic feed, thin-window (85μg/cm^2) 20 minutes.	Tennelec model 5100 automatic feed, thin-window, 125 minutes.	Differences in radiation detector models' operation and maintenance, and standard count-times can have significant impacts on counting efficiency and resulting MDC. Larger detectors and longer count times increase sensitivity of the measurement.
Calibration isotope gross alpha analyses	Thorium-230	Thorium-230	Plutonium-239	Thorium-230	In general, a lower energy standard would result in a slightly higher reported concentration.
Calibration isotope gross beta analyses	Cesium-137	Cesium-137	Cesium-137	Cesium-137	In general, a lower energy standard would result in a slightly higher reported concentration.
Filtration	Not Filtered	Not Filtered	Not Filtered	Filtered	Samples that are not filtered include dissolved and suspended constituents, which may result in a higher concentration than filtered samples containing only the dissolved fraction.
Preservation	Nitric acid added in the field	Nitric acid added in the field	Nitric acid added in the field	Nitric acid added in the field	Preserving the sample in the field may prevent the radionuclides dissolved in the sample from adhering to the sample container, which could result in a lower measured concentration in the unpreserved sample.

a. The lower the energy of the decay particle, the less efficient the detector. Because the concentration is determined by dividing the number of counts by the efficiency, calibration with a lower energy particle yields a higher concentration. Peak energies are listed below (from Shleien, 1992).(1) americium-241: 5.49 MeV alpha particle (85%) (2). strontium-90/yttrium-90: 2.28 MeV beta particle (yttrium-90, 100%) (3) plutonium-239: 5.16 MeV alpha particle (73%) (4). 0 .55 MeV beta particle (strontium-90, 100%) (5). thorium-230: 4.69 MeV alpha particle (76%) (6). cesium-137: 1.17 MeV beta particle (5%) 0.51 MeV beta particle (95%).

Table 5-6. Summary of linear regression[a] parameters with 95% confidence intervals for the replicate samples collected by INEEL OP, USGS, and ESER, 2000.

Analyte	Co-sampling Agency	Slope	y-intercept	R	p	SD of the predicted value	Number of replicate sample sets
Gross Alpha	ESER	-0.02 ± 0.06	0.57 ± 0.13	-0.114	0.7534	0.390	10
	USGS (INEEL)[b]	-0.04 ± 0.04	1.68 ± 0.09	-0.177	0.3490	0.346	30
	USGS (MV)[c]	0.06 ± 0.10	1.01 ± 0.17	0.138	0.5609	0.652	20
Gross Beta	ESER	1.06 ± 0.52	2.28 ± 1.04	0.580	0.0785	1.563	10
	USGS (INEEL)[b]	1.09 ± 0.28	2.29 ± 0.52	0.590	0.0006	1.69	30
	USGS (MV)[c]	1.63 ± 0.25	1.89 ± 0.88	0.835	<0.0001	1.90	20
Cesium-137	USGS (INEEL)[b]	1.62 ± 3.81	1.22 ± 4.66	0.0718	0.6727	25.4	37
Tritium	ESER	0.97 ± 0.60	-8.0 ± 22.9	0.4967	0.1442	71.4	10
	USGS (INEEL)[b]	0.96 ± 0.01	-106 ± 48	0.997	<0.0001	336	65
	USGS (MV)[c]	0.06 ± 0.09	25.3 ± 3.99	0.149	0.5308	16.6	20
	USGS (MV)[cd]	0.83 ± 0.11	4.64 ± 3.51	0.865	<0.0001	8.42	20
Strontium-90	USGS (INEEL)[b]	1.10 ± 0.30	-1.62 ± 2.72	0.882	0.0202	4.33	6

a. Regressions highlighted are those that are meaningful.
b. Locations on and near the INEEL.
c. Distant, Magic Valley locations.
d. Tritium analyzed using an electrolytic enhancement.

Table 5-7. Summary of paired t-tests for replicate samples analyses, 2000.

Analyte	Co-sampling Agency	Mean of Data (pCi/L)	Variance of data	Number of Replicate Samples	t-statistic	Probability (P-Value)	Conclusion (at 95% Probability
Gross Alpha							
	OP with ESER	0.43 0.57	4.05 0.17	10	-0.21	0.8378	Means are not significantly different
	OP with USGS (INEEL)[a]	1.51 1.63	2.50 0.12	30	-0.37	0.7140	Means are not significantly different
	OP with USGS (MV)[b]	0.99 1.06	2.40 0.41	20	-0.22	0.8256	Means are not significantly different
Gross Beta							
	OP with ESER	1.75 4.14	0.98 3.28	10	-5.12	0.0063	Means are significantly different
	OP with USGS (INEEL)[a]	1.47 3.9	1.23 4.23	30	-8.00	<0.0004	Means are significantly different
	OP with USGS (MV)[b]	Compared by linear regression					
Cesium-137							
	OP with USGS (INEEL)[a]	0.55 2.11	1.23 629	37	-0.38	0.7067	Means are not significantly different
Tritium							
	OP with ESER	-7 -13	1561 6020	10	0.37	0.7213	Means are not significantly different
	OP with USGS (INEEL)[a]	Compared by linear regression					
	OP with USGS (MV)[b]	17 26	1956 267	20	-0.97	0.3657	Means are not significantly different
Tritium[c]							
	OP with USGS (MV)[c]	Compared by linear regression					
Strontium-90							
	OP with USGS (INEEL)[a]	Compared by linear regression					

a. Locations on and near the INEEL.
b. Distant, Magic Valley locations.
c. Tritium analyzed using an electrolytic enhancement

Table 5-8. Summary of mean differences between results of replicate pairs, 2000.

Analyte	Co-sampling Agency	Mean difference (INEEL OP) (pCi/L)	Standard Deviation	Number of replicate pairs
Gross alpha				
	ESER	0.14	2.01	10
	USGS (INEEL)[a]	0.12	1.68	30
	USGS (MV)[b]	0.08	1.59	20
Gross beta				
	ESER	2.39	1.48	10
	USGS (INEEL)[a]	2.43	1.66	30
	USGS (MV)[b]		Compared by linear regression	
Cesium-137				
	USGS (INEEL)[a]	1.56	25	37
Tritium				
	ESER	-7.8	67	10
	USGS (INEEL)[a]		Compared by linear regression	
	USGS (MV)[b]	9.3	45	20
Tritium[c]				
	USGS (MV)[b]		Compared by linear regression	
Strontium-90				
	USGS (INEEL)[a]		Compared by linear regression	

a. Locations on and near the INEEL
b. Magic Valley sampling locations
c. Tritium measured using an Electrolytic Enhancement Method

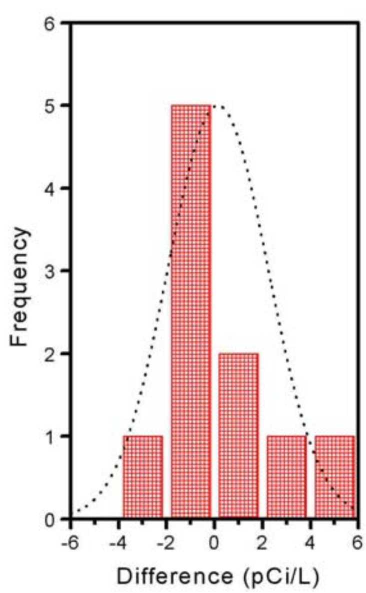

Figure 5-10. Histogram of differences between INEEL OP and ESER for gross alpha radioactivity, 2000.

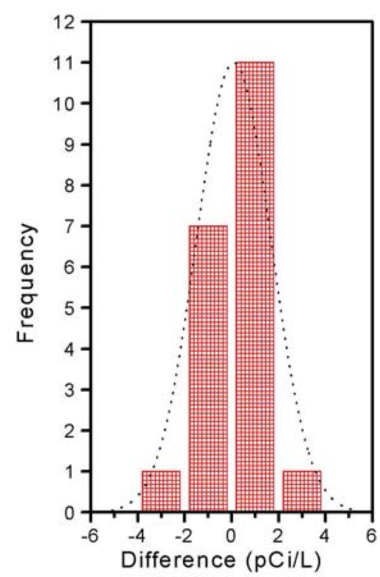

Figure 5-11. Histogram of differences between INEEL OP and USGS in the Magic Valley for gross alpha, 2000.

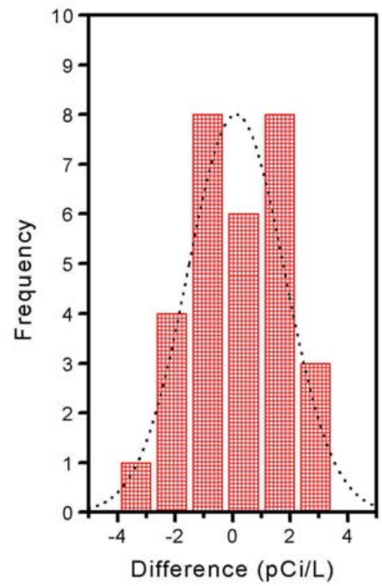

Figure 5-12. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross alpha radioactivity, 2000.

Gross Beta Radioactivity

A total of 60 replicate results for gross beta radioactivity was available: 10 co-sampled with ESER, 30 with the USGS on and near the INEEL, and 20 with the USGS in the Magic Valley. Regression results were meaningful for gross beta radioactivity compared with the USGS in the Magic Valley. The regression, shown in **Figure 5-13**, resulted in a best-fit line with a slope of 1.63 " 0.25 and a y-intercept that did not bound zero.

While the regression line appears to weigh heavily on a single high data pair, the regression met criteria for a "good" regression. The slope of the regression line suggests that USGS results typically show more gross beta radioactivity than INEEL OP results. A regression recomputed without the one high USGS data value resulted in a best fit line with a correlation coefficient that failed the test for good regression (0.73) and a slope much closer to 1 (1.20 ± 0.28). A paired t-test computed for all 20 replicate data pairs indicated that the means are different, and a computed mean difference for these pairs was 3.8 pCi/L. While the regression is weak compared to most other regressions presented here (e.g., tritium for INEEL OP and the USGS on the INEEL), the information provided does not contradict conclusions from further statistical testing that was conducted. The regression met the criteria for being "good." T-test and difference results are not presented here for Magic Valley results.

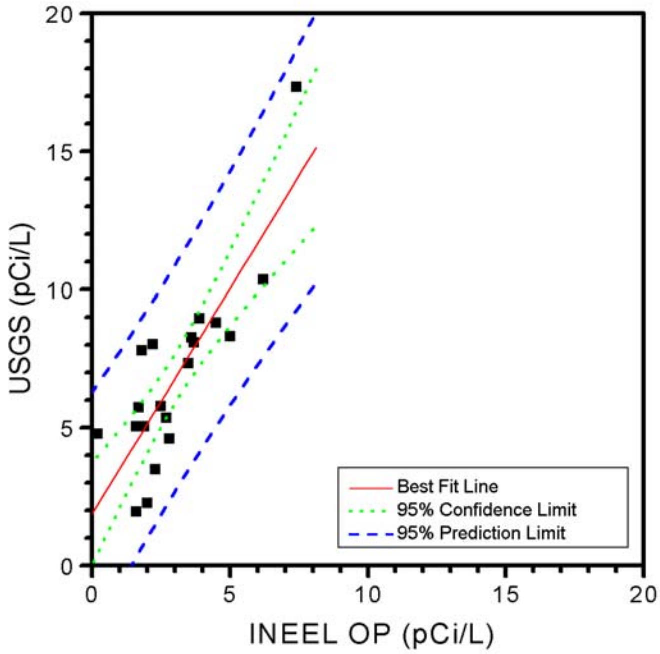

Figure 5-13. Comparison of INEEL OP and USGS results for gross beta radioactivity in the Magic Valley, 2000

Paired t-test analyses, noted in **Table 5-7**, indicated that at a 95% confidence level, the mean of gross beta radioactivity measurements made by the INEEL OP are different from that of ESER and the USGS on and near the INEEL.

Differences between replicate samples for gross beta radioactivity, presented in **Table 5-8**, showed that INEEL OP results for 2000 were less than those of ESER and the USGS on and near the INEEL, with differences roughly equal to the sample-specific MDC. This difference is consistent with comparisons from previous years. Histograms of these differences are presented in **Figures 5-14** and **5-15**. Contributing factors for observed differences between ESER and USGS results and those of INEEL OP include detector size, count times, and calibration isotopes.

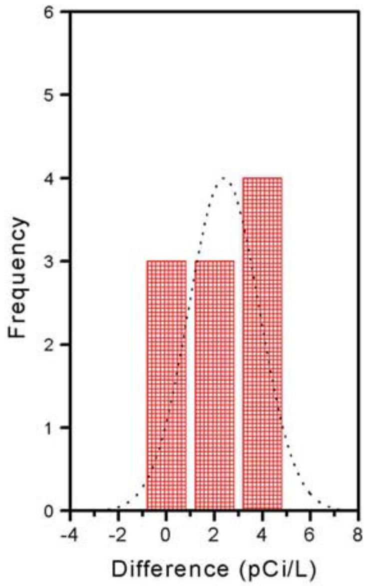

Figure 5-14. Histogram of differences between INEEL OP and ESER for gross beta radioactivity, 2000.

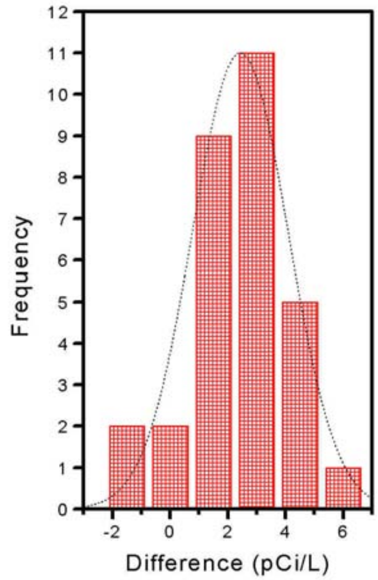

Figure 5-15. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross beta radioactivity, 2000.

Cesium-137

All of the 37 replicate results available for cesium-137 were replicates with the USGS on the INEEL. Regression analysis was not meaningful, as noted on **Table 5-6**. Paired t-test analysis indicated that the means were not significantly different for cesium-137 analyses at a 95% confidence level. Mean differences, presented in **Table 5-8**, show that the USGS results on the INEEL were typically greater than the INEEL OP results--a difference likely due to the level of resolution (relatively high MDC) of the USGS results, about 2 orders of magnitude greater than INEEL OP results for cesium-137. **Figure 5-16** presents the histogram of these results.

Tritium

A total of 95 replicate results for tritium was available: 10 co-sampled with ESER, 65 with the USGS on and near the INEEL, and 20 with the USGS in the Magic Valley. As indicated in **Table 6-6**, regression results were not meaningful for locations co-sampled with the ESER and with the USGS in the Magic Valley, but were meaningful for locations co-sampled with the USGS on and near the INEEL.

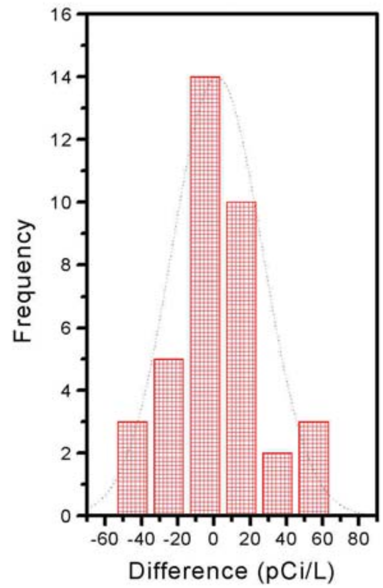

Figure 5-16. Histogram of differences between INEEL OP and USGS cesium-137 concentrations on and near the INEEL, 2000.

The regression results for sites co-sampled with the USGS on and near the INEEL (**Figure 5-17)** demonstrate very good agreement. While indicating very good agreement (0.96 ± 0.1), the slope of the regression line for compared 2000 replicate samples was not quite as good as in previous years where slopes bounding 1 have been typical. Likewise, the y-intercept for 2000 comparisons does not bound zero, unlike previous years. However, regression analysis results still indicate very good agreement between INEEL OP and USGS tritium results.

Replicate tritium results for ESER and USGS in the Magic Valley, compared using t-tests, were not significantly different from INEEL OP results. Histograms of these differences are presented in **Figures 5-18** and **5-19.**

As the MDC for standard tritium analyses for ESER and INEEL OP compared here is greater than the environmental levels observed for sites cosampled with ESER and with the USGS in the Magic Valley, this comparison is more a comparison of laboratory background determinations. The methods used by ISU-EML and the laboratories used by ESER and the USGS for sample sites on and near the INEEL use a standard liquid scintillation method to analyze for tritium. This method typically results in an MDC of about 160 to 250 pCi/L. Results from samples analyzed by the standard liquid scintillation method are precise enough to readily distinguish INEEL tritium from typical background levels under most circumstances.

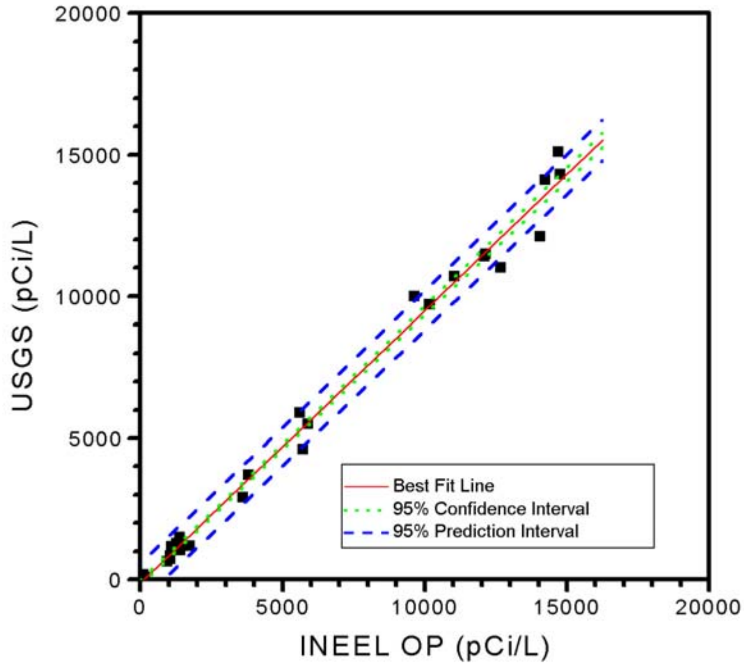

Figure 5-17. Comparison of replicate tritium results for INEEL OP and USGS for sites on and near the INEEL, 2000.

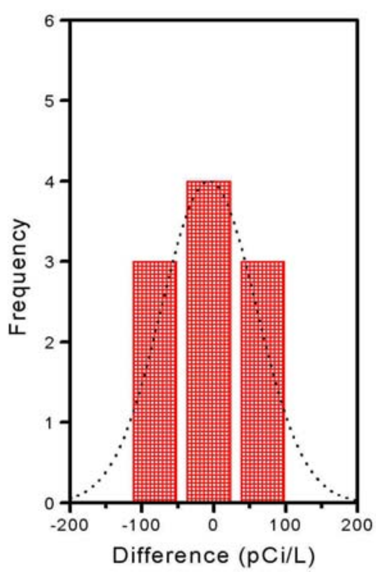

Figure 5-18. Histogram of differences between INEEL OP and ESER in the Magic Valley for Tritium, 2000.

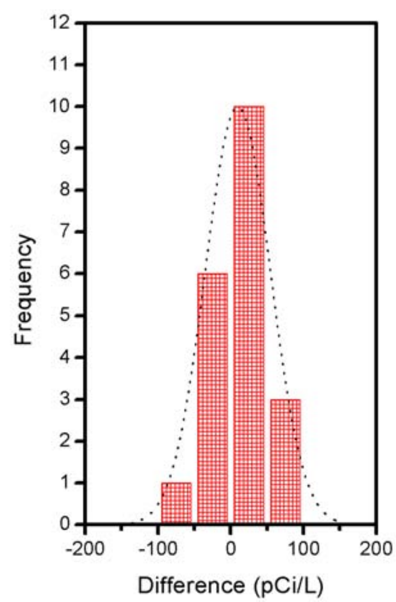

Figure 5-19. Histogram of differences between INEEL OP and USGS Magic Valley for Tritium by the standard method, 2000

Enhanced Tritium

The USGS National Water Quality Laboratory uses an enrichment and gas counting method to measure tritium at very low levels. This method, with an MDC about 100 times lower than liquid scintillation alone, is best suited for tritium at very low levels, referred to as environmental-level or enhanced tritium. ISU EML uses an electrolytic enrichment method to concentrate tritium in samples. This enrichment method lowers sample MDCs to less than 25 pCi/L, which is within the range typically observed for background levels of tritium.

A total of 20 replicate environmental-level tritium samples was collected with the USGS in the Magic Valley. These results were compared with the tritium analysis results from the USGS National Water Quality Laboratory (**Figure 5-20**). The regression for low-level tritium results from ISU-EML and the USGS were comparable, with a slope of 0.83 " 0.11, and a y-intercept nearly bounding zero. The slope suggests that INEEL OP enhanced tritium results from ISU-EML were typically about 17% higher than USGS' Magic Valley results. This difference is greater than observed in other years. This regression is strongly influenced by a single data point. A replicate pair returned a result of 51 ± 8 pCi/L for the INEEL OP sample, and 17 ± 1.6 pCi/L for the USGS result. Historical trends for this location suggest that the INEEL OP result was higher than previous samples. Laboratory review failed to find any problems with this result. Omitting this data point and recomputing the regression substantially improves the correlation coefficient and gives a slope more comparable with previous comparisons. INEEL OP and ISU-EML work closely during data review and validation to try to correct any analytical errors we find, however, unexplained errors as well as natural variability could both produce the discrepancy observed for this sample pair. Even with this one suspect replicate pair, the observed regression still shows good agreement between INEEL OP and USGS environmental tritium results.

Strontium-90

Six replicate results for strontium-90 for four locations co-sampled with the USGS on the INEEL were compared. Regression analysis of these data, shown on **Figure 5-21**, correlate reasonably well for such a small number of compared samples. The regression slope was 1.10 " 0.30, suggesting that INEEL OP results for strontium-90, which are conducted by Teledyne, a laboratory on subcontract to ISU-EML, were generally 10% less than results from the USGS, identical to the comparison of results from 1999.

Plutonium-238, 239/240

There were no co-sampled results where plutonium isotopes were detected in both contractor and INEEL OP samples.

Summary of Differences

While statistically significant differences (at the 95% confidence level) were observed for gross alpha, gross beta, cesium-137, and tritium replicate results, these differences were relatively small compared to the concentrations observed. **Figure 5-22** summarizes the relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

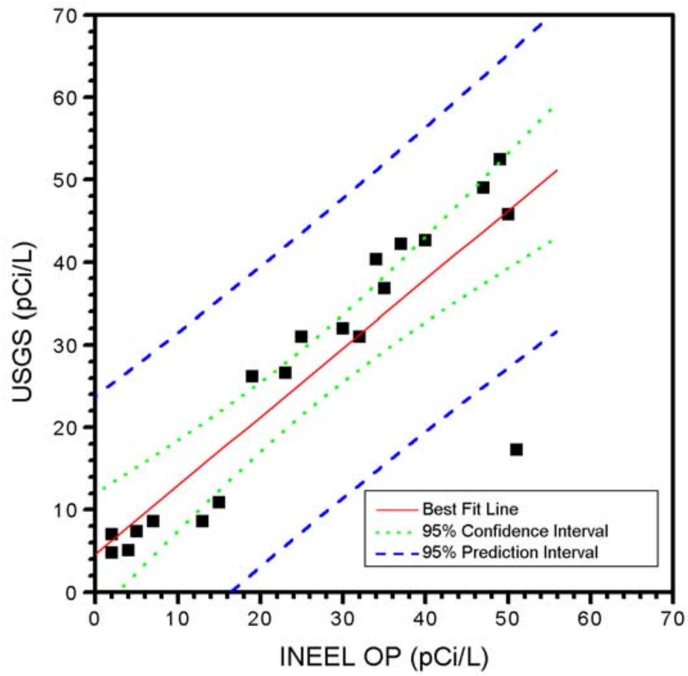

Figure 5-20 Comparison of replicate results for tritium by enrichment and gas counting for the USGS MV and by electrolytic enrichment and liquid scintillation for INEEL OP, in the Magic Valley, 2000.

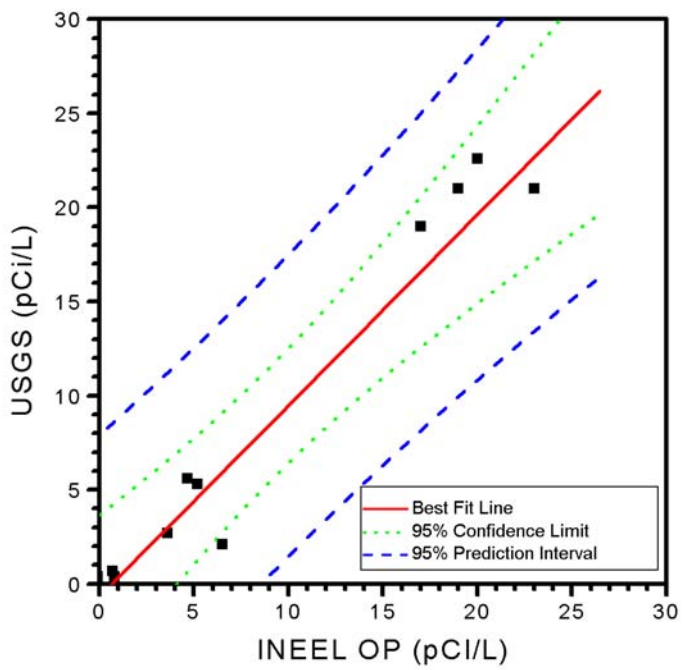

Figure 5-21 Comparison of replicate results for strontium-90, INEEL OP and USGS on and near the INEEL, 2000.

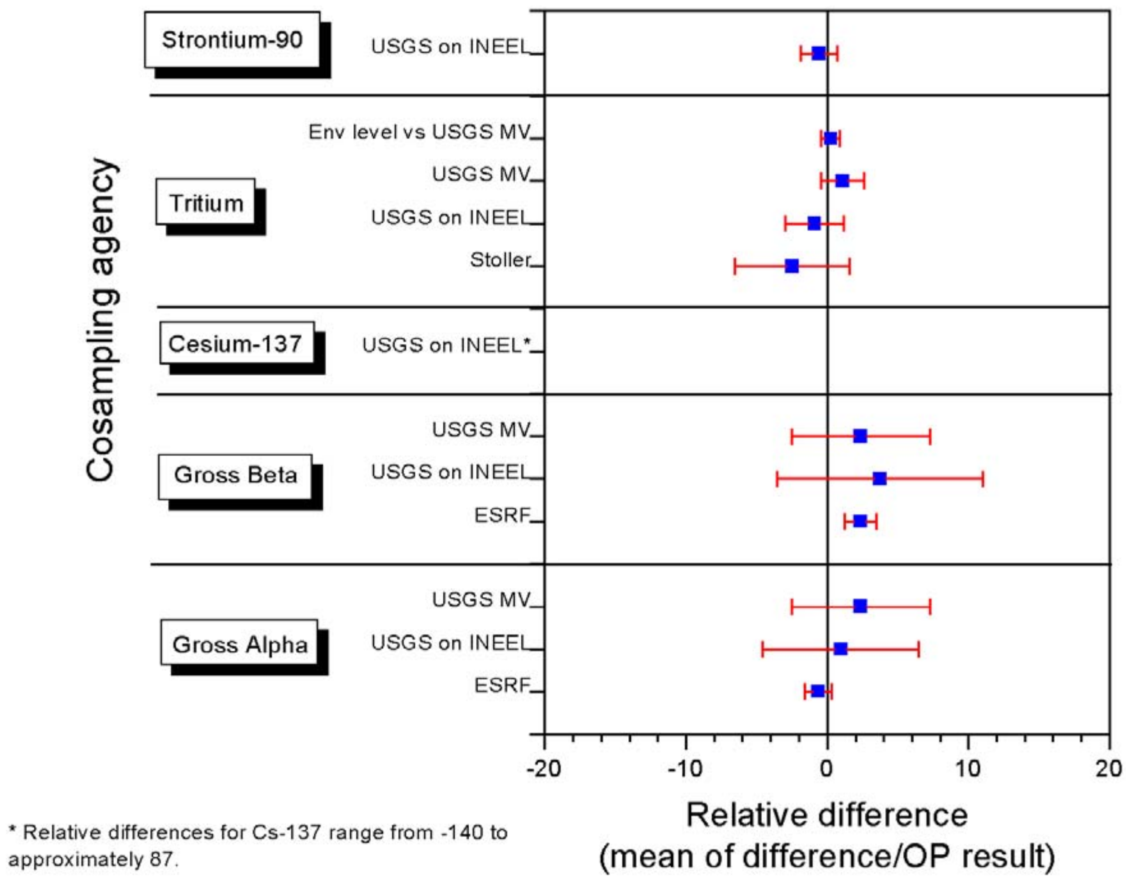

Figure 5-22. Summary of relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

The x-axis shows the mean and standard deviation of differences between individual program results divided by the INEEL OP results for that data pair for each analyte. Dividing by the INEEL OP result serves to normalize the differences with the computation result being a "relative mean difference."

The mean relative differences, with only one exception, are within one standard deviation of the zero difference line. Only relative differences for gross beta radioactivity compared with ESER fail to compare within one standard deviation of the zero-difference line, however, the relative difference is still small (<5%).

The range of relative differences are less than about 12% with one exception. This exception is cesium-137 compared with the USGS on and near the INEEL. The difference between INEEL OP and USGS MDC concentrations can explain the wide range of relative difference (-140 to 87) and a mean difference of -26 observed. The MDC for USGS onsite locations was nearly 100 times that reported for comparative INEEL OP cesium-137 results. The resulting data and counting uncertainties for compared samples differed by 1 to 2 orders of magnitude. While the reporting level for these USGS cesium-137 results may be sufficient for identifying cesium-137 contamination at risk-based levels, the reporting level for INEEL OP cesium-137 results is better suited to identifying this radionuclide at lower levels. Such differences in level of precision, due to factors such as different laboratory analytical methods, counting times, or sample sizes, are typically not useful for program comparison. However, such results do provide an informative example of the impact that differences in analytical methods can have on a given set of data.

In conclusion, while comparison of replicate radiological results with ESER and with the USGS on and near the INEEL and in the Magic Valley did show some differences, the biases appeared relatively small and could be explained by differences in laboratory and sample collection methods. In general, comparison of results from these co-sampling organizations verified that, while replicate results obtained by these agencies and INEEL OP were not identical, they were in good agreement.

References

Bartholomay, R.C., B.R. Orr, M.J. Liszewski, and R.G. Jensen. *Hydrologic Conditions and Distribution of Selected Radiochemical and Chemical Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho, 1989 through 1991*. U.S. Geological Survey Water-Resources Investigations Report 95-4175 (DOE/ID-22123), 1995.

Bartholomay, R.C., B.J. Tucker, D.J. Ackerman, and M.J. Liszewski. *Hydrologic Conditions and Distribution of Selected Radiochemical and Chemical Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho, 1992 through 1995*. U.S. Geological Survey Water-Resources Investigations Report 97-4086 (DOE/ID-22123), 1997.

Eisenbud, M., and T. Gesell. *Environmental Radioactivity from Natural, Industrial, and Military Sources*. 4th Ed. Academic Press,1997.

Hall, L. F. *Comparison of Major Ion Water Chemistry for the State of Idaho INEEL Oversight Program Environmental Surveillance Water Monitoring Data Upgradient (USGS 27 and Mud Lake Water Supply) With Data From other Sources*. State of Idaho INEEL Oversight Program. OP-99-01, 1999.

Hem, J.D. *Study and Interpretation of the Chemical Characteristics of Natural Water*. U.S. Geological Survey Water-Supply Paper 2254. 1985.

Idaho State University Environmental Monitoring Laboratory. *Technitium-99 Measurement Using 3M^{TM} Empore^{TM} Rad Disks*. July 1, 2000.

Knobel, L.L., B.R. Orr, and L.D. Cecil. *Summary of Background Concentrations of Selected Radiochemical and Chemical Constituents in Groundwater from the Snake River Plain Aquifer, Idaho.* Estimated from an analysis of previously published data: Journal of the Idaho Academy of Sciences. 28 (June 1992)

Knobel, L.L., R. S. Bartholomay, B. J. Tucker, L. M. Williams and L. D. Cecil. *Chemical Constituents in Groundwater from 39 Selected Sites with an Evaluation of Associated Quality Assurance Date, Idaho.* U.S. Geological Survey Open-File Report 99-246 (DOE/ID-22159), 1999

Mann, L.J. Radionuclides, *Metals, and Organic Compounds in Water, Eastern Part of the A&B Irrigation District, Minidoka County, Idaho*. U.S. Geological Survey Open-File Report 90-191 (DOE/ID-22087), 1990.

Michel, R.J. *Tritium Deposition in the Continental United States 1953-1983*. USGS Water Resources Investigation Report 89-4072, 1989.

Orr, B.R., D.L. Cecil, and L.L. Knobel. *Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical Constituents in Groundwater in the Vicinity of the Idaho National Engineering Laboratory.* U.S. Geological Survey Water-Resources Investigations Report 91-4015 (DOE/ID-22094), 1991.

Rupart, M.G. *Nitrate (NO2+ NO3-N) in Ground Water of the Upper Snake River Basin, Idaho and Western Wyoming 1991-95.* U.S. Geological Survey Water Resources Investigations Report 97-4174. 1997.

Rupart, M.G.. *Analysis of Data on Nutrients and Organic Compounds in Groundwater in the Upper Snake River Basin, Idaho and Wyoming, 1980-91.* U.S. Geological Survey. Water Resources Investigations Report 94-4135.

Robertson, J.B., R. Schoen, and J.T. Barraclough. *The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho:1952-1970*, U.S. Geological Survey Open File Report IDO-22053, 1974.

Salvato, J.A. *Environmental Engineering and Sanitation*. 4th Ed, John Wiley and Sons, Inc. 1992.

United States. Environmental Protection Agency. *Contract Laboratory Program National functional guidelines for Inorganic Data Review.* EPA 540/R-94/013, 1994.

United States. Environmental Protection Agency. *National Drinking Water Regulations. Code of Federal Regulations*, Chapter 40, Part 141 and 143, 1997.

Wood, W.W., and W.H. Low. *Solute Geochemistry of the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon*. U.S. Geological Survey Professional Paper 1408-D, 1989.

Chapter 6

Verification Water Monitoring Program

In 2000, the INEEL OP collected 34 replicate groundwater and wastewater samples with the DOE's primary contractor at the INEEL (BBWI), and the monitoring groups at ANL-W and NRF.

- Most of the results reported by the INEEL OP were comparable to those reported by BBWI, ANL-W, and NRF. The observed differences were generally attributable to sample heterogeneity or the use of different analytical methods.

Introduction

In 2000, the INEEL OP continued collecting replicate water samples with the BBWI as well as the monitoring groups at ANL-W and NRF to verify the analytical data reported by these organizations. Sampling is limited to long-term monitoring programs such as those developed for CERCLA Records of Decision (RODs), RCRA Wastewater Land Application Permits (WLAP), and environmental surveillance. The sampling program was not designed to duplicate the DOE's extensive sampling network, but rather to collect a sufficient number of samples, typically about 10%, to provide an additional level of confidence in the analytical data reported by the DOE. During 2000, the INEEL OP collected 34 replicate samples at the 18 groundwater and 12 wastewater locations shown in **Figure 2-6** in **Chapter 2**. USGS-55 is a perched water well; the other groundwater wells sampled are in the Snake River Plain Aquifer. The analytical results are summarized in **Table 6-1.**

Because the samples are collected for various purposes (WLAP, CERCLA, etc.), the analytes and analytical methods are variable. Therefore, the interprogram comparison is performed on a per sample basis; that is, each analytical result is compared directly to the result reported by the INEEL OP. The interprogram comparisons are somewhat tenuous given the limited sample populations; but the program will likely expand as additional CERCLA-post-ROD monitoring plans are developed.

Table 6-1. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2000.

Analyte	Range of Concentrations				Drinking Water Standard[a]
	Wastewater		Groundwater		
	Minimum	Maximum	Minimum	Maximum	
Common Ions (mg/L)					
Alkalinity (as CaCO3)	109	678	115	204	None
Calcium	8.4	1558	40	103	None
Chloride	13.0	12679	2.6	161	SMCL=250
Fluoride	<0.1	0.83	0.26	0.81	SMCL=2
Magnesium	1.0	478	11.0	26.8	None
Potassium	2.4	44.0	2.3	5.3	None
Silica	15.1	68.3	22.3	36.6	None
Sodium	9.0	7000	5.9	87	None
Sulfate	15.5	418	14.9	103	SMCL=250
Total Dissolved Solids	200	25223	193	711	SMCL=500
Total Suspended Solids	<1	203	<1	8	None
Nutrients (mg/L)					
Ammonia (as N)	6.09	11.7	<0.005	0.008	None
Nitrate (as N)	<0.01	0.997	0.372	2.353	10
Nitrite (as N)	<0.005	0.329	<0.005	0.007	1
Nitrite+Nitrate (as N)	0.013	7.27	0.378	2.93	10
Phosphate (as P)	0.092	3.71	0.013	0.256	None
Total Kjeldahl N (TKN)	6.09	18.4	<0.05	0.14	None
Trace Metals (μg/L)					
Aluminum	<50	700	<50	1370	SMCL=50-200
Antimony	<5	13	<5	<5	6
Arsenic	<10	11	<10	<10	50
Barium	13	2630	52	238	2000
Beryllium	<1	<1	<1	<1	4
Cadmium	<1	<1	<1	<1	5
Chromium	<5	21	<5	152	100
Cobalt	<5	<5	<5	<5	None
Copper	<10	30	<10	20	SMCL=1000
Iron	<10	830	<10	2420	SMCL=300
Lead	<5	<5	<5	11	AL=15
Manganese	<1	438	<1	18	SMCL=50
Mercury	<0.5	<0.5	<0.5	<0.5	2
Nickel	<5	9	<5	9	100
Selenium	<5	<25	<5	<5	50

Table 6-1 continued. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2000.

Analyte	Range of Concentrations				Drinking Water Standard[a]
	Wastewater		Groundwater		
	Minimum	Maximum	Minimum	Maximum	
Silver	<1	2	<1	<1	None
Thallium	<1.5	<7.5	<1.5	<1.5	2
Vanadium	<100	<100	<100	<100	None
Zinc	8	95	<5	1680	SMCL=5000
Volatile Organic Compounds (μg/L)[b]					
1,1-Dichloroethene	NR[c]	NR	<0.5	2.97	7
Cis-1,2,-Dichloroethene	NR	NR	<0.5	72.1	70
Trans-1,2-Dichloroethene	NR	NR	<0.5	55.3	100
Methylene Chloride	NR	NR	<0.5	8.0	5
Tetrachloroethene	NR	NR	<0.5	84.1	5
Trichloroethene	NR	NR	<0.5	811	5
Radionuclides (pCi/L)[d]					
Cesium-137	<MDC	28.1±2.5	<MDC	<MDC	200
Cobalt-60	<MDC	<MDC	<MDC	8.7±2.3	100
Gross Alpha (as Am-241)	<MDC	46.1±6.4	<MDC	4.0±2.1	15
Gross Beta (as Cs-137)	<MDC	57.1±2.3	<MDC	69.2±2.2	200[e]
Strontium-90	<MDC	<MDC	<MDC	19.0±3.0	8
Tritium	<MDC	<MDC	<MDC	45670±450	20000

a. Maximum contaminant level (MCL) unless otherwise noted. AL=Action Level from Lead and Copper Rule; SMCL=Secondary maximum contaminant level.
b. List limited to analytes detected in at least one sample. See Table 7-3 for a complete list of analytes.
c. NR=Not requested
d. Counting uncertainty reported at 2s.
e. For beta-emitters, the maximum contaminant level is expressed as a cumulative annual dose of 4 millirem/year; for cesium-137, this is equivalent to 200 pCi/L, if cesium-137 were the only radionuclide detected.

Comparison of Nonradiological Results

For non-radionuclide analyses, if the reported concentration of the analyte exceeded the detection limit by a factor of five or more in both samples, the relative percent difference (RPD) between the two analytical results was calculated using the following equation:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where:
C_1 = reported concentration of the analyte in the sample collected by the INEEL OP
C_2 = reported concentration of the analyte in the sample collected by the contractor

An RPD of #25% is considered acceptable for inorganics, and an RPD of #40% is acceptable for organic compounds. For replicate samples in which one, or both, of the results reported for a particular analyte are less than five times the detection limit, the results are considered comparable if the two results differ by an amount equal to or less than twice the detection limit. These comparison criteria are based primarily on the degree of accuracy the EPA requires for internal matrix spikes at their contract laboratories (EPA, 1994; 1994a). The INEEL OP has adopted these standards as guidelines. If less than 90% of the replicates for a particular analyte meet the desired level of accuracy, the results are investigated further.

Less that 90% of the replicate samples for 13 analytes were considered comparable (**Table 6-2)**.

All replicate sample pairs for chloride, copper, nitrate, sulfate, total dissolved solids, and total suspended solids that failed the comparison criteria were wastewater samples. The differences in the analytical results for these wastewater samples are likely due to sample heterogeneity, which is of particular concern in unfiltered samples.

Furthermore, all three of the replicate pairs that failed the comparison criteria for copper were wastewater samples from the NRF Industrial Waste Ditch. Upon further inspection, it appears that the observed differences in these data are due to the fact that the IBL did not immediately recognize the analytical interference from the very high calcium and magnesium concentrations in these samples. The IBL corrected this in 2001, and raised the detection limit for copper in wastewater samples from the NRF Industrial Waste Ditch from 10 μg/L to 100 μg/L. At the higher detection limit, two of the three samples from the ditch would be considered comparable.

The majority of the replicate pairs for TKN and zinc which failed the comparison criteria were also wastewater samples. Four of the six replicate pairs for TKN that were not comparable were wastewater samples. The TKN results were discussed with the representatives from the IBL, who suspected that the differences were due to variation in the amount of total suspended solids in the samples. Zinc is a common constituent in plumbing fixtures (e.g., galvanized pipe) thus the observed differences are also attributable to sample heterogeneity.

Three of the seven replicate pairs for iron that failed the comparison criteria were groundwater samples and four were wastewater samples. Because the analyses are performed on unfiltered samples, differences in the amount of particulate iron (e.g., rust and basalt fragments), in the replicate samples can cause significant differences in the reported iron concentration. For example, the INEEL OP collected a duplicate sample at well NRF-6 and the reported iron concentrations in the first sample and the duplicate were 340 μg/L and 660 μg/L, respectively.

Phosphate (as phosphorus) also failed the criteria of $90% comparable results. The results reported by the NRF for three of the five replicate pairs that were not comparable were qualified as estimated values due to relatively minor quality assurance concerns.

Similarly, one of the two results for barium that failed the comparison criteria was qualified. The other was from a wastewater sample, suggesting sample heterogeneity.

Table 6-2. Comparison of concentrations of common ions, nutrients, and trace metals reported for replicate samples collected with the ANL-W, BBWI, and NRF, 2000.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 25%, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Common Ions				
Alkalinity (as $CaCO_3$)	2	2	2	100
Calcium	7	7	6	86
Chloride	22	22	18	82
Fluoride	11	7	10	91
Magnesium	10	10	10	100
Potassium	7	7	7	100
Silica	1	1	1	100
Sodium	21	21	19	90
Sulfate	20	20	16	80
Total Dissolved Solids	15	15	13	87
Total Suspended Solids	10	8	6	60
Nutrients				
Ammonia (as N)	5	3	4	80
Nitrate (as N)	9	7	8	89
Nitrite (as N)	12	1	11	92
Nitrite+Nitrate (as N)	16	16	15	94
Phosphate (as P)	19	16	14	74
Total Kjeldahl N (TKN)	18	10	6	67
Trace Metals				
Aluminum	15	1	15	100
Antimony	15	1	15	100
Arsenic	19	1	19	100
Barium	18	18	16	89
Beryllium	15	0	15	100
Cadmium	21	0	21	100
Chromium	23	11	23	100
Cobalt	6	0	6	100
Copper	17	2	14	82
Iron	20	16	13	65
Lead	18	1	18	100
Manganese	18	10	17	94
Mercury	25	0	25	100
Nickel	15	3	15	100
Selenium	19	0	19	100
Silver	17	1	17	100
Thallium	15	0	15	100
Vanadium	6	0	6	100
Zinc	17	12	12	71

Only one replicate pair for calcium and ammonia failed the criteria.

Of the volatile organic compounds (VOCs) for which results were reported by both the INEEL OP and the other organizations, trans-1,2-dichloroethene (trans-1,2-DCE) and tetrachloroethene (PCE) did not meet the criteria of $90% comparable results (**Table 6-3**). The differences were discussed with representatives from the IBL, who suggested that the VOC analyses actually compared quite well given the numerous variables in the analyses. Specifically, they noted that:

1. The two detectors at the IBL do not always agree, thus the analyst must decide which result he/she has the most confidence in. For example, in one of the replicate samples which failed the comparison criteria, the detectors yielded results of 4.20 and 15.1 µg/L trans-1,2-DCE, and 16.1 and 40.9 µg/L PCE. The analyst felt that the detector reporting the lower concentrations was more accurate and reported those values. However, the higher concentrations would compare more favorably with the results reported by BBWI: 14.1 µg/L and 41.35 µg/L of trans-1,2-DCE and PCE, respectively.

2. The two labs use different analytical methods. The DOE contractor lab uses gas chromatography/mass spectrometry. The IBL uses only gas chromatography.

3. Cis-1,2-dichloroethene and trans-1,2-dichloroethene can volatilize from the sample very rapidly.

4. Additional analytical error can be introduced if dilutions are necessary on samples with large concentrations.

Table 6-3. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2000.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 40%, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Benzene	5	0	5	100
Bromobenzene	4	0	4	100
Bromochloromoethane	4	0	4	100
Bromodichloromethane	5	0	5	100
Bromoform	5	0	5	100
Bromomethane	5	0	5	100
n-Butylbenzene	0	0	0	NA
sec-Butylbenzene	4	0	4	100
tert-Butylbenzene	4	0	4	100
Carbon tetrachloride	5	0	5	100
Chlorobenzene	5	0	5	100
Chloroethane	5	0	5	100
Chloroform	5	0	5	100
Chloromethane	5	0	5	100
2-Chlorotoluene	4	0	4	100
4-Chlorotoluene	4	0	4	100
Dibromochloromethane	5	0	5	100
1,2-Dibromo-3-chloropropane	5	0	5	100
1,2-Dibromoethane	5	0	5	100

Table 6-3. continued. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2000.

Analyte	**Number of replicate sample pairs**	**Number of pairs where analyte detected in both samples**	**Number of replicate pairs where relative percent difference ≤ 40%, or where results are within twice the detection limit**	**Percent of replicate samples with comparable results**
Dibromomethane	4	0	4	100
1,2-Dichlorobenzene	5	0	5	100
1,3-Dichlorobenzene	5	0	5	100
1,4-Dichlorobenzene	5	0	5	100
Dichlorodifluoromethane	5	0	5	100
1,1-Dichloroethane	5	0	5	100
1,2-Dichloroethane	5	0	5	100
1,1-Dichloroethene	5	0	5	100
cis-1,2-Dichloroethene	10	3	9	90
trans-1,2-Dichloroethene	10	3	8	80
1,2-Dichloropropane	5	0	5	100
1,3-Dichloropropane	4	0	4	100
2,2-Dichloropropane	4	0	4	100
1,1-Dichloropropene	4	0	4	100
cis-1,3-Dichloropropene	5	0	5	100
trans-1,3-Dichloropropene	5	0	5	100
Ethylbenzene	5	0	5	100
Hexachlorobutadiene	4	0	4	100
Isopropylbenzene	5	0	5	100
p-Isopropyltoluene	0	0	0	NA
Methylene chloride	4	0	4	100
Naphthalene	5	0	5	100
n-Propylbenzene	4	0	4	100
Styrene	5	0	5	100
1,1,1,2-Tetrachloroethane	4	0	4	100
1,1,2,2-Tetrachloroethane	5	0	5	100
Tetrachloroethene	10	5	5	50
Toluene	5	0	5	100
1,2,3-Trichlorobenzene	4	0	4	100
1,2,4-Trichlorobenzene	5	0	5	100
1,1,1-Trichloroethane	5	0	5	100
1,1,2-Trichloroethane	5	0	5	100
Trichloroethene	10	5	9	90
Trichlorofluoromethane	5	0	5	100
1,2,3-Tricholopropane	4	0	4	100
1,2,4-Trimethylbenzene	4	0	4	100
1,3,5-Trimethylbenzene	4	0	4	100
Vinyl chloride	10	0	10	100
Xylenes (total)	5	0	5	100

Comparison of Radiological Analyses

Unlike the nonradioactive constituents for which analytical error is not reported, the analytical (counting) error must be considered when evaluating radioactivity analyses. Therefore, the results reported for the replicate radionuclide analyses are considered to be comparable if either:

1) $|C_1\text{-}C_2| \#3(s_1^2+s_2^2)^{1/2}$
where:

C_1 = reported concentration of the analyte in the sample collected by the INEEL OP
C_2 = reported concentration of the analyte in the sample collected by the contractor
s_1 = sample standard deviation of the INEEL OP sample
s_2 = sample standard deviation of the contractor sample
or
2) the relative percent difference (RPD) was less than or equal to 20%.

The approach outlined above is used by the ISU EML to determine whether the results of its duplicate analyses are within control limits.

As shown in **Table 6-4**, the gross alpha and gross beta screening results were the only radiological analyses that did not meet the comparison criteria.

The differences in the gross alpha analyses are attributed to normal analytical variability or sample heterogeneity. In each of the two replicate pairs that failed the comparison criteria, the INEEL OP reported a concentration below the detection limit while the other sampling group reported a concentration slightly above the detection limit. At one of these locations the co-sampling organization detected gross alpha radioactivity in their first sample but not the duplicate.

The INEEL OP reported a lower gross beta concentration than BBWI and NRF in all but one of the replicate pairs. This bias has also been noted in replicate pairs collected with other agencies such as the USGS and ESER, but the cause has not yet been determined. Differences in the size of detectors, window density thickness, calibration isotopes, and development of mass adsorption curves may all be contributing factors.

Table 6-4. Comparison of radionuclide concentrations reported for replicate samples collected with ANL-W, BBWI, and NRF, 2000.

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 20%, or where results are within three times the weighted counting error	Percent of replicate samples with comparable results
Cs-137	13	0	12	92
Gross Alpha	11	2	9	82
Gross Beta	11	9	6	55
Strontium-90	6	0	6	100
Tritium	16	7	15	94

References

EPA (U.S. Environmental Protection Agency). USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA 540/R-94/013, 1994.

EPA (U.S. Environmental Protection Agency). USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. EPA 540/R-94/012, 1994a.

Chapter 7

External Radiation Monitoring

Major Findings and Developments

Ambient penetrating exposure measurements performed during 2000 were consistent with historical background measurements. Redundancy in data collection and use of passive radiation detectors provided adequate cumulative average exposure rates at each gamma monitoring location.

- No off-site environmental impacts from INEEL operations were detected with environmental ambient gamma radiation exposure-rate measurements.
- Interprogram comparisons of different surveillance program results show good agreement. Discrepancies are attributable to differences in monitoring schedules and different penetrating radiation measurement techniques.

Primary Penetrating Radiation Monitoring Results and Trends

The INEEL OP monitors ambient exposure rates using a network of real-time high-pressure ion chambers (HPIC) and electret ion chambers (EIC). While each of the detection systems measures penetrating radiation, the HPIC data measure real-time exposure rates which can be used to calculate hourly, daily, weekly, monthly, quarterly, and annual average exposure rates. EIC data reflect cumulative dose for the period of time during which the device is deployed. Penetrating radiation exposure measurements were within levels typically accepted as background. Penetrating radiation measurements at these locations are expected to range from 9 to 15 :R/h due to cosmic radiation and gamma radiation from radionuclides that occur naturally in the soil. Exposure rates are estimated using cosmic ray response reported by the HPIC manufacturer and using exposure rate dose coefficients provided in NCRP 94 for radionuclide concentrations in local soil.

Routine Penetrating Radiation Measurements

INEEL OP routinely monitors penetrating radiation at 15 locations. Of these locations, INEEL OP operates 11 HPICs and the Shoshone-Bannock tribes operate a HPIC at the Fort Hall Community Monitoring Station. Multiple EICs are deployed at each of these locations.

No significant impacts to the environment were identified using the HPIC radiation monitoring network. Average exposure rates observed using HPICs ranged from 10.5 to 13.9 :R/h and average exposure rates observed using EICs ranged from 13.7 to 23.6 :R/h (as shown in **Figure 7-1** and **Table 7-1**). Due to differences in construction, the EIC is somewhat more responsive to low-energy photons and exposure rates are typically 30 to 40 percent greater than those observed using the HPIC. Additionally, a systematic negative bias was observed during the HPIC annual source checks (**Table 7-3**). The cause of this bias is being investigated.

Supplemental Radiation Measurements

INEEL OP deploys EICs at 80 additional locations to supplement the radiation-monitoring network. Some of the EICs are deployed at radiation monitoring locations maintained by BBWI and ESER for verification purposes. Also, EICs are deployed at several locations on the INEEL, along the INEEL boundary, and at distant locations to provide additional technical information for emergency response efforts in the event of an accidental radiological release associated with INEEL operations. Supplemental radiation measurements ranged from 9.4 to 31.1 :R/h with an average exposure rate of 18.0 :R/h, median exposure rate of 17.7 :R/h, and a sample standard deviation of 4.2 :R/h. These measurements were similar to those observed in historical EIC measurements.

During 2000, the penetrating radiation monitoring program experienced equipment problems. An updated data logging system developed software and hardware problems that were difficult to resolve. These problems stress the continued need for redundancy in the ambient gamma-monitoring program. This also stresses the importance of having a reliable, passive gamma-monitoring network to supplement the real-time gamma-monitoring program.

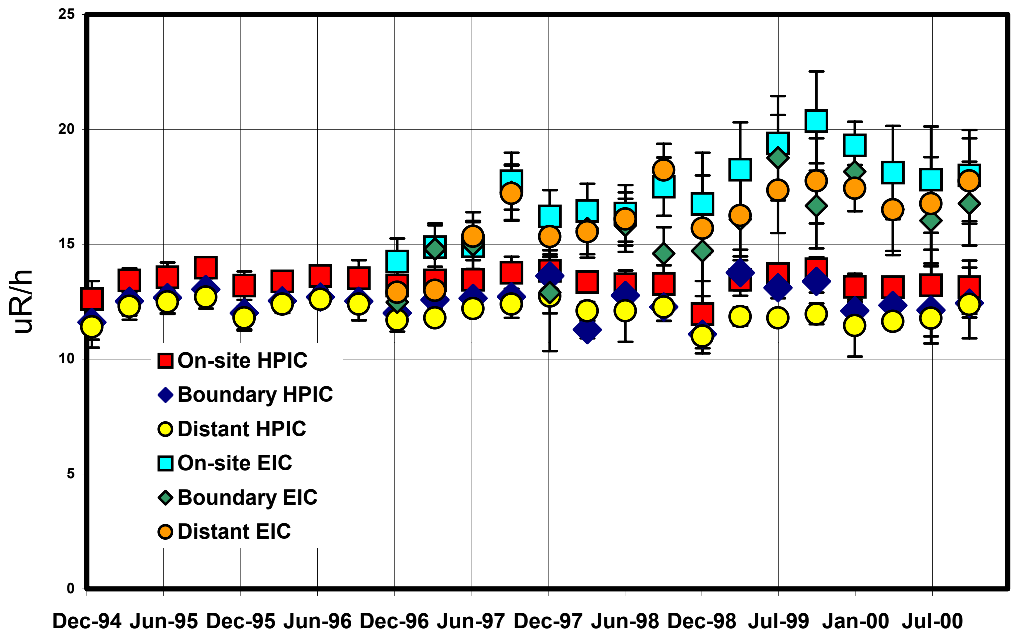

Figure 7-1. Average routine quarterly exposure rates observed by high-pressure ion chambers and electret ion chambers deployed by INEEL OP since 1994.

Table 7-1. Average quarterly exposure rates, 2000.

Location	Average HPIC Exposure Rates (μR/h)	Expected HPIC Response[a] (μR/h)	Average EIC Exposure Rates (μR/h)
Atomic City	12.3 to 13.0	12.5	15.7 to 16.3
Base of Howe Peak	12.3	12.3	15.1 to 16.2
Big Southern Butte	12.0 to 13.2	12.7	15.1 to 19.2
Fort Hall[b]	12.4 to 12.7	12.5	18.2 to 21.4
Howe	12.1 to 12.6	9.0	15.1 to 17.8
Idaho Falls	10.5 to 11.2	11.6	13.7 to 15.2
Main Gate	13.5 to 13.9	12.7	17.2 to 19.3
Monteview	10.7 to 11.0	11.0	15.0 to 21.8
Mud Lake/Terreton	12.3 to 12.7	13.2	15.2 to 20.1
Big Lost River Rest Area	13.2 to 13.5	12.8	16.8 to 19.2
Rover	13.1 to 13.3	12.3	17.1 to 18.9
Sand Dunes Tower	12.8 to 13.3	12.2	17.3 to 21.0
Craters of the Moon	NA[c]		15.1 to 15.8
Experimental Field Station	NA[c]		18.1 to 21.2
Van Buren Avenue	NA[c]		19.6 to 23.6

[a] Estimated from radionuclide concentrations in soil and HPIC elevation.
[b] HPIC owned, operated, and maintained by Shoshone-Bannock tribes.
[c] Not Applicable, INEEL OP does not operate a HPIC at this location.

Problems were encountered at the Big Lost River Rest Area resulting from a range fire that damaged electrical cables and damaged utility poles supplying power to the monitoring station. Several EICs were damaged during the range fires as well. The HPIC at the Big Southern Butte monitoring station was out of calibration and was replaced with a HPIC recently calibrated by the manufacturer.

Quality Assurance

Electret Ion Chambers

To verify EIC response, INEEL OP has EICs irradiated with known and “blind” gamma exposures. For quality assurance (QA) purposes, irradiations of QA EICs are conducted by ISU EML to a known exposure of 30 mR and a “blind” exposure ranging from 20 to 50 mR (“blind” in the context that INEEL OP does not decide the exposure received). EIC response using the factory E-PERM™ calibration factors is compared directly with the exposure received from the NIST traceable Cs-137 source used by ISU EML for these irradiations. EIC response is considered acceptable if each irradiated EIC agrees within 10% or within 3 standard deviations. **Table 7-2** shows irradiation results for 2000 and **Figure 7-2** shows a graphic representation of EIC response with exposure received.

High-Pressure Ion Chambers

Annual source checks were conducted at each HPIC deployed as part of the penetrating radiation monitoring network. The source check involves the direct comparison of instrument response to a gamma source between the HPIC deployed in the field and a “mobile” HPIC calibrated by the manufacturer. The results of this source check are shown in **Table 7-3**.

Table 7-2. EIC response resulting from QA irradiations performed at Idaho State University for 2000. Relative Difference values correspond to the relative differences of net measured exposures with respect to exposure received.

Calendar Quarter 2000	Exposure Received (mR)	Uncertainty (mR)	Net Measured Exposure (mR)	Uncertainty (mR)	Relative Difference
1st Quarter	30.0	1.5	27.8	1.6	-7.4%
1st Quarter	50.1	2.5	46.6	1.5	-7.0%
2nd Quarter	30.0	1.5	28.6	1.9	-4.6%
2nd Quarter	20.0	1.0	18.7	2.2	-6.4%
3rd Quarter	29.1	1.5	28.1	0.8	-3.5%
3rd Quarter	45.5	2.3	43.3	2.4	-4.8%
4th Quarter	30.0	1.5	28.7	0.3	-4.3%
4th Quarter	25.0	1.3	24.2	0.9	-3.3%

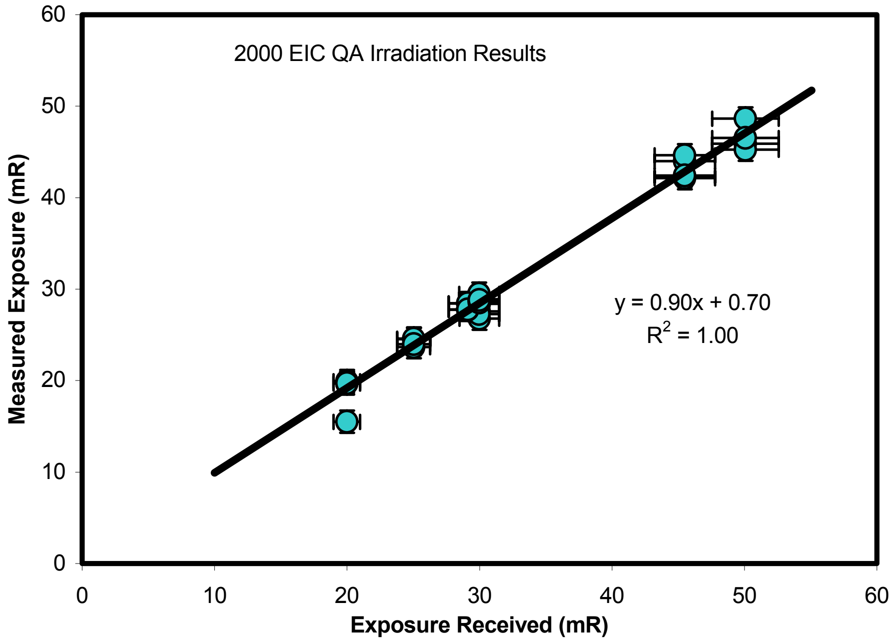

Figure 7-2. EIC response using manufacturer's calibration factors with respect to irradiations conducted at ISU during 2000. This plot demonstrates a strong agreement between measured exposure and exposure received. Each EIC responded within 10% of the received exposure with variations likely due to minor statistical fluctuations**.**

Table 7-3. HPIC instrument response results with respect to a portable HPIC calibrated by the manufacturer.

HPIC Monitoring Location	Date Performed	Relative Difference with respect to Calibrated HPIC
Atomic City	July 11	-7.5%
Base of Howe	June 5	-7.7%
Big Lost River Rest Area	October 24	-4.3%
Big Southern Butte[a]	July 10	-10.5%
Fort Hall CMS[b]	May 30	-1.9%
Howe Met Tower	October 31	-6.4%
Idaho Falls	June 1	-7.1%
Main Gate	November 16	-3.4%
Monteview	August 8	-0.2%
Mud Lake/Terreton	August 22	-7.7%
Rover	June 5	-5.8%
Sand Dunes Tower	October 24	-9.0%

[a] HPIC deployed in the field was replaced with another HPIC calibrated by the manufacturer.
[b] HPIC is owned, maintained, and operated by Shoshone-Bannock tribes.

Comparison of External Radiation Monitoring Results Reported by DOE Contractor

Penetrating radiation measurements demonstrated good agreement between the three environmental radiation exposure surveillance programs monitoring on and around the INEEL. In 2000, BBWI and ESER used thermoluminescent dosimeters to determine cumulative exposures over a period of time. BBWI and ESER deployed Lithium Fluoride (LiF) TLDs, which were collected on a six-month cycle, and INEEL OP deployed EICs which were collected on a three-month cycle. Measurements are considered in agreement if the reported values agree within 3-sigma measurement uncertainty or ten percent relative difference. A summary of this comparison is shown in **Table 7-4**.

Table 7-4. Comparison results between reported passive radiation measurement results.

	Percent in Agreement	Average Relative Difference [a]	Number of Measurements Compared
INEEL OP vs. BBWI	98%	-10.4%	57
INEEL OP vs. ESER	100%	-2.0%	26

[a] relative difference with respect to the mean of the two values

No comparisons of real-time HPIC data were made due to the lack of co-located HPICs.

Although the gamma results reported by the INEEL OP, BBWI, and ESER in 2000 fell within levels accepted as background, direct comparisons of the programs' results provide qualitative correlations between the data sets. **Figure 7-3** shows a Quantile-Quantile plot of co-located INEEL OP EICs and BBWI TLDs comparing 2000 radiation exposure measurements. **Figure 7-4** shows a Quantile-Quantile plot of co-located INEEL OP EICs and ESER TLDs comparing 2000 radiation exposure measurements.

The comparison results illustrated in **Figures 7-3** and **7-4** reflect interprogram variations in monitoring schedules and monitoring techniques. Deployment periods used by INEEL OP did not precisely match the deployment periods used by either BBWI or ESER. INEEL OP deploys passive EICs at the beginning of each calendar quarter for the duration of that calendar quarter. BBWI and ESER deploy TLDs for 6-month deployment periods from November to May and May to November.

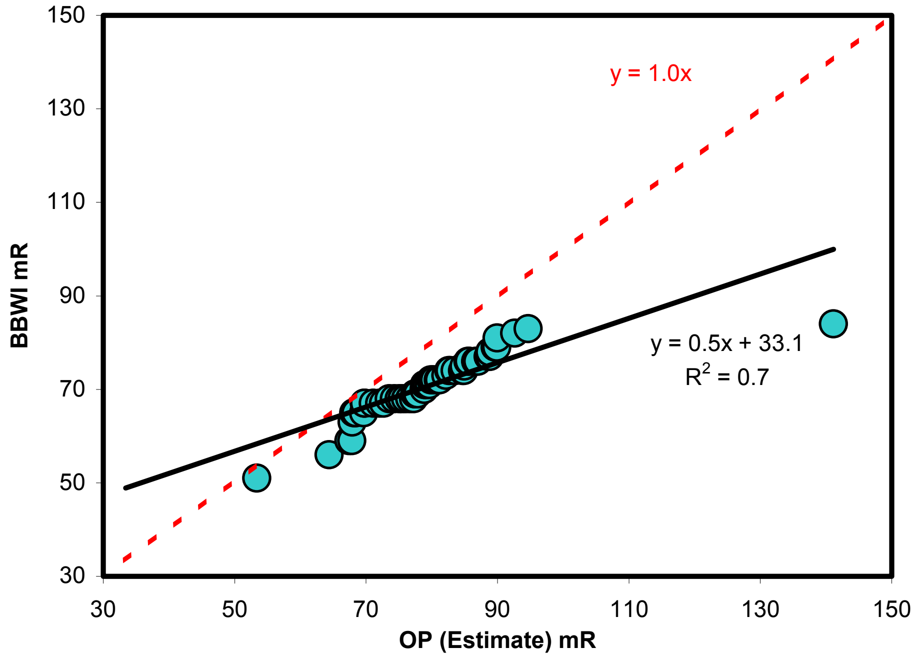

Figure 7-3. Quantile-Quantile Plot comparing BBWI TLD measurements and INEEL OP EIC measurements at co-located monitoring sites. Differences are expected due to variations in deployment and monitoring schedules and types of passive dosimeters used. Dotted line indicates ideal regression.

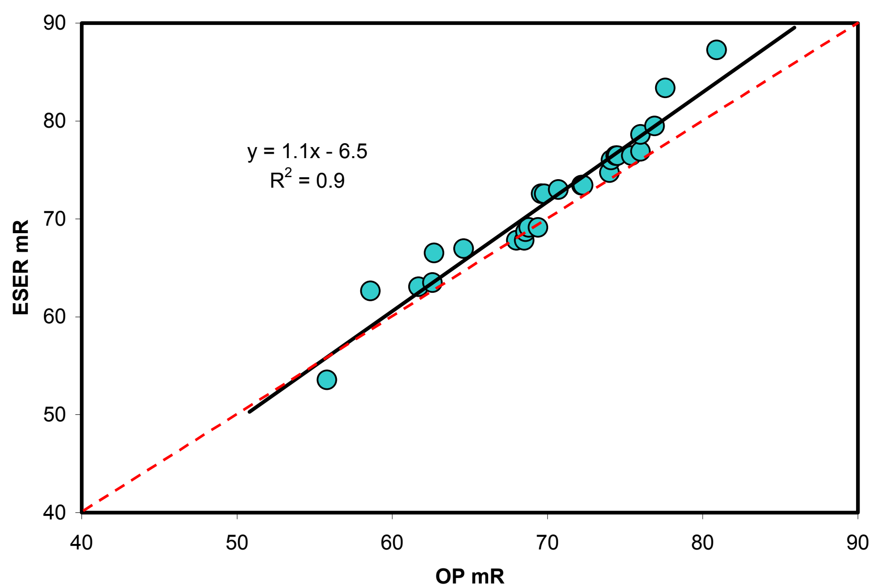

Figure 7-4. Quantile-Quantile Plot comparing ESER TLD measurements and INEEL OP EIC measurements at co-located monitoring sites. Differences are expected due to variations in deployment and monitoring schedules and types of passive dosimeters used. Dotted line represents the ideal regression.

Conclusion

Environmental monitoring of penetrating radiation indicated no impact to the environment as a result of INEEL operations during 2000. During the summer of 2000, problems were experienced during range fires on the INEEL including damage to HPIC electrical cables, destruction of EICs, and an extended period of electrical power loss at one of the monitoring stations on the INEEL.

Overall, the DOE-ID environmental radiation monitoring results are consistent with INEEL OP environmental radiation monitoring results. Slight variations were expected due to differences in monitoring periods and differences in monitoring methods.

References

National Council on Radiation Protection and Measurements. *Exposure of the Population in the United States and Canada from Natural Background Radiation.* Report No. 94, December 1987.

Reuter-Stokes. *RSS-1013 PIC Environmental Radiation Monitoring Station Operational Manual*. Version 1.4, May 1993.

Chapter 8
Conclusions

Conclusions

Having completed an independent assessment of the environmental conditions at the INEEL to provide verification of DOE monitoring results for 2000, the INEEL OP concludes:

- At monitoring locations on and near the INEEL, gamma radiation measurements remained within background levels.
- While no contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley monitoring sites, INEEL impacts can be identified at some well sites along the southern boundary of the INEEL. However, concentrations were less than one percent of the EPA drinking water limit.
- Results from contaminants in groundwater and soil from past releases, and airborne tritium from 2000 emissions, remained well below regulatory limits, with the exception of some on-site groundwater results measuring above drinking water standards. Notably, none of these wells were used for consumption of water by humans or animals.
- Because of Pu-238, 239/240 detections in a special study, two wells were added to the verification water sampling program for 2001.
- Comparisons of results reported by INEEL OP and DOE surveillance programs generally agree.

Appendix A
The Design and Development of the INEEL Oversight Program's Environmental Surveillance Program

History and Legislative Authority

In the late 1980s, at a time when facts about contamination from a half century of defense-related production were gradually coming to light, and DOE's credibility with state governments was consequently deteriorating, the U.S. Secretary of Energy proposed the concept of oversight roles for states hosting DOE facilities. Under this new proposal, the states would be given access to DOE facilities and information so that each state could conduct independent assessments of the potential environmental impacts resulting from DOE activities. The details of such arrangements were to be negotiated in agreements-in-principle (AIP), wherein DOE would obligate funds to ensure that states could carry out their oversight responsibilities.

On April 5, 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL, and on May 1, 1990, the State of Idaho and the DOE signed a five-year AIP entitled the Environmental Oversight and Monitoring Agreement (State of Idaho-DOE 1990). This agreement provided grant funding and other resources for establishing and supporting the State's INEEL OP, which was assigned the following responsibilities:

- Secure necessary data and information regarding DOE activities in Idaho;
- Scientifically evaluate this information in the context of total INEEL impacts on the public and environment; and
- Objectively report conclusions to the people of Idaho.

When the first AIP grant expired in 1995, the State of Idaho, the DOE, and the NRF negotiated a subsequent five-year AIP, which reinforced the fundamental elements of the program and built on the experience gained during the first five years of INEEL OP operations. INEEL OP, the DOE and NRF negotiated another subsequent five-year AIP in 2000.

By working cooperatively with the DOE, the INEEL OP has developed a successful program that includes a strategic monitoring network designed to supplement and verify DOE's environmental monitoring data, which allows the State of Idaho to provide independent oversight and surveillance of the environment and DOE activities at the INEEL.

Environmental Surveillance Program Network Design

The INEEL OP surveillance network selectively and independently collects samples of environmental media that could be contaminated by activities at the INEEL. Media sampled include air, surface water, groundwater, soil, and milk. The evolution of the INEEL OP monitoring network is summarized below.

Air Monitoring

The INEEL OP air monitoring network was created through a research and development agreement with DOE to conduct independent air monitoring activities on and around the INEEL.

By evaluating meteorological records, results from dispersion models, and the locations of actual or potential air emission sources at INEEL, the program identified potential off-site locations for six permanent air quality monitoring stations. Four of these sites were situated around the perimeter of the INEEL at Mud Lake, Monteview, Howe, and Atomic City. A fifth site was established on the INEEL at the Big Lost River Rest Area on U.S. Highway 20/26. Initially, these five sites were equipped with low-volume particulate samplers loaned to the INEEL OP by the U.S. Environmental Protection Agency (EPA). In 1992, these samplers were replaced with similar samplers, acquired from DOE's contractor surplus, which INEEL OP operated according to quality assurance quality control and standard operating procedures. The sixth site, in Idaho Falls, was added to the network in the fall of 1992 to serve as a distant background monitoring location. Collectively, these six stations now serve as permanent monitoring stations in the air surveillance program.

In January of 1994, following DOE's decision to privatize its environmental surveillance program, the INEEL OP incorporated the four ISU Environmental Monitoring Program air-monitoring stations into its network. These stations, previously operated by ISU for DOE, included three locations on the INEEL--Sand Dunes Tower, Experimental Field Station, and Van Buren Avenue--and one off-site location at the Craters of the Moon National Monument. **Figure 2-1** in **Chapter 2** of this report provides the exact locations of these sites.

Currently, the network instrumentation of the ten air monitoring stations includes samplers to collect airborne particulate matter smaller than ten micrometers in diameter (PM_{10}), atmospheric moisture, and gaseous radioiodine. Precipitation samplers operate at six of the ten monitoring stations to collect samples for radiological analyses.

External Radiation Monitoring

Each of the ten air monitoring stations described above is further equipped with an environmental dosimeter to measure time-integrated exposure to gamma radiation. For real-time measurement of ambient gamma radiation, the six original stations also employ high-pressurized ion chambers, from which data can be relayed via radio transmitter to the INEEL OP Idaho Falls office.

Expanding the radiation monitoring network in 1995, the INEEL OP applied historical meteorological data and dispersion modeling information to the process of selecting strategic locations for additional radiation monitoring stations. Now in place at Rover, the Base of Howe Peak, the Main Gate, and near Big Southern Butte, these stations include both environmental dosimeters and high-pressurized ion chambers, and, with the exception of the Main Gate location, are powered by solar energy. The exact locations of these sites are shown on **Figure 2-2** in Chapter **2** of this report.

In 1999, the INEEL OP implemented a new type of environmental dosimeter to replace the thermoluminescent dosimeters previously used. Electret ion chambers (EIC) were deployed at the six original stations, the four stations formerly operated by ISU, and Rover, the Base of Howe Peak, the Main Gate, and near Big Southern Butte. In addition, EICs are deployed around the perimeter of the INEEL approximately every two miles and at NOAA mesonet towers throughout southeastern Idaho for a total of 82 locations. The locations of these sites are shown on **Figure 2-2** in **Chapter 2** of this report.

Terrestrial Media Monitoring

Deposition of radioactive material released from INEEL facilities to the air can cause accumulation and migration of radionuclides in the environment that may lead to human exposure or adverse environmental impacts. Terrestrial media that can be sampled to assess potential human and environmental exposure to deposited radioactive material includes but is not limited to soil, vegetation, and milk.

The methodology used by the INEEL OP to identify terrestrial monitoring locations included an assessment of potential INEEL facility air emission characteristics, the evaluation of monitoring activities by other agencies, and careful consideration of INEEL OP objectives. Initially, soil monitoring locations were selected to further characterize the environment around the permanent air monitoring stations. Co-locating these two sampling activities supported comparisons of related background and long-term data trends. Periodically, an *in-situ* gamma spectrometer could be employed to determine background radiation information at co-located sampling locations.

Water Monitoring

Contamination of the Snake River Plain Aquifer underlying the INEEL is generally limited to areas near TAN, INTEC, TRA, CFA, and RWMC. In these areas, the concentration of one or more contaminants in the aquifer approaches or exceeds federal drinking water standards. Because the USGS has been monitoring water quality at the INEEL since 1949, many of the more than 300 wells presently used to monitor the Snake River Plain Aquifer in the vicinity of the INEEL are observation wells originally installed by the USGS.

The INEEL OP water surveillance network combined two previously existing surveillance programs in 1993. The first, established by the ISU Environmental Monitoring Program in 1989, had previously conducted replicate sampling with DOE contractors and the USGS INEEL Project Office at 23 locations on and off the INEEL. The second, a cooperative program between the USGS and the Idaho Department of Water Resources (IDWR), performed sampling to determine the quality of water in the Snake River Plain Aquifer between the southern boundary of the INEEL and the Thousand Springs area along the Snake River near Hagerman. Merging these two surveillance programs, the INEEL OP assumed monitoring responsibilities from the ISU Environmental Monitoring Program, funded a position in IDWR to cover the expenses of collecting samples south of the INEEL, and implemented a three-year rotation sampling schedule for 55 sites. In addition, the INEEL OP water surveillance program initiated a new sampling program in 1999 to co-sample wastewater and groundwater collected by BBWI, ANL-W and NRF on the INEEL.

Over the past five years, the INEEL OP has expanded the number of monitoring locations originated by the surveillance programs and will continue to selectively add wells or springs to the network when one or more of the following criteria are met:

- Water from the location is used by the public;
- The location provides long-term community monitoring trends;
- Sampling from the location verifies and supplements monitoring by the INEEL contractor; and/or
- The location provides information at critical points along the groundwater pathway.

Currently, the INEEL OP collects water samples from 76 wells, 8 springs, and 3 surface water locations on and off the INEEL. With regard to the new wastewater and groundwater sampling program begun in 2000, 12 wastewater sites and 18 groundwater sites were sampled. Additional information regarding the specific locations, sampling schedules, and co-sampling organizations associated with the water monitoring program is provided in **Chapter 2** of this report.

Appendix B: Glossary, Acronyms and Units

Glossary

A priori—Prior to measurement.

Accuracy—The degree of agreement of a measured value with the --true-- or expected value.

Activation products—Isotopes produced from the absorption by nuclei of neutrons in a nuclear reactor.

Activity—See radioactivity.

Alpha particle—Particle that is emitted from the nucleus of an atom, and contains two protons and two neutrons. Identical to the nucleus of a helium atom, without the electrons, an alpha particle is a form of radiation that can travel only a few millimeters in air, and be stopped by a piece of paper. Uranium-238, radium-226, and polonium-210 are all alpha emitters.

Atom—The smallest particle of an element that retains all the chemical and physical characteristics of that element. Every known atom consists of negatively charged electrons traveling around a nucleus. The nucleus, or core, of an atom contains protons, which are positively charged, and neutrons, which are uncharged.

Atomic weight—A number that identifies a specific isotope numerically equal to the number of protons and neutrons in the isotope. For example, the “90” in strontium-90 indicates a total of 90 protons and neutrons in the nucleus.

Background—Naturally occurring or constantly present radioactivity or chemical species in an environment. Cosmic rays and terrestrial radiation are two contributors to natural background.

Beta particle—A high-speed particle, identical to an electron, that is emitted from the nucleus of an atom. Beta radiation can be stopped by a thin sheet of metal about the thickness of foil. Strontium-90, cesium-137, and tritium are beta emitters.

Committed effective dose equivalent—The dose equivalent that will accumulate during the 50 years following the intake of a radionuclide.

Confidence interval—The range of values that may be expected to encompass the true value.

Cosmic radiation—Radiation which permeates all of space, from sources primarily outside our solar system. The radiation is in many forms, from high-speed, heavy particles to high-energy photons. Examples of cosmogenic radionuclides are carbon-14, tritium, and beryllium-7.

Cosmogenic radioactivity—Unstable atoms resulting from the interaction between cosmic radiation and atoms in the atmosphere. Examples of cosmogenic radionuclides include carbon-14, tritium, and beryllium.

Decay—The spontaneous transformation of one nuclide into a different nuclide or a different energy state of the same nuclide. For a radioactive nuclide, this transformation process results in the emission of nuclear radiation, such as alpha, beta, or gamma radiation.

Decay chain—The series of different nuclides into which a nuclide will change until a stable nuclide has been formed. During decay, nuclides may transform many times.

Disintegration—See decay.

Dose—A measurement of the quantity of energy absorbed per unit mass from any kind of ionizing radiation, also called absorbed dose. The traditional unit of absorbed dose is the rad.

Duplicate sample—A second sample randomly selected from a population of interest to assist in the evaluation of sample variation.

Effective dose equivalent—The summation of the weighting factor for tissue multiplied by the dose equivalent to tissue.

Electret ion chamber—An ionization chamber made up of polypropylene plastic which provides a nearly air-equivalent chamber. EICs are used to measure cumulative total of environmental gamma radiation exposure.

Exposure—A measure of ionization produced in air by x-rays or gamma rays. Unlike dose, exposure refers to the potential of receiving radiation. The traditional unit is the roentgen.

Fission—The splitting of nuclei by neutrons.

Gamma rays—Electromagnetic waves or photons emitted from the nucleus of an atom. Gamma radiation is very penetrating and is best attenuated by dense materials such as lead. Technetium-99m is used for medical imaging. Technetium-99m is a soft beta emitter.

Gamma spectroscopy—Technique used to determine the distribution of radionuclides in a sample. Gamma spectroscopy identifies radionuclides since the gamma ray spectrum is characteristic for the radionuclides present in the sample.

Gas-flow proportional counting—Technique used to make gross alpha and gross beta screening measurements in a sample. Uses a gas-filled detector under certain conditions. Under these conditions, the number of counts in the detector is proportional to the number of ionization events taking place.

Gross alpha—Total alpha activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Gross beta—Total beta activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Half-life—The time it takes for one half of the atoms of a particular radionuclide to decay into another nuclear form. Measured half-lives vary from less than millionths of a second to billions of years.

Health physics—The interdisciplinary science and application of science for the radiation protection of humans and the environment. Health physics combines the elements of physics, biology, chemistry, statistics and electronic instrumentation to provide information that can be used to protect individuals from the effects of radiation.

High-pressure ionization chamber—A pressurized ion chamber is a sensitive photon detector capable of real-time measurements and provides real-time environmental gamma radiation exposure measurements.

In situ gamma spectroscopy—Gamma spectroscopic measurements performed *in situ*. The detector is placed directly over the area being analyzed. The advantage to this technique is that samples are not taken, which, in turn, minimizes the potential for cross-contamination and waste production.

Injection well—A well used for the disposal of wastewater.

Ionization—The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions (charged particles). High temperature, electrical discharge, nuclear radiation, and x-rays can cause ionization.

Ionizing radiation—Radiation with enough energy to remove tightly bound electrons from their orbits during an interaction with an atom, causing the atom to become charged or ionized.

Isotope—One of two or more atoms that have the same number of protons but a different number of neutrons in their nuclei. The atoms have nearly the same chemical properties, but their physical properties often differ. A radioactive isotope is called a radioisotope.

Liquid scintillation counting—A counting technique used to measure low-energy beta particles or alpha particles that involves the dissolution of the sample to be counted directly into a liquid scintillator.

Low-level radioactive waste—Waste that does not generally require shielding or heat removal, usually possessing small transuranic content.

Mean—Arithmetical average of a set of numbers.

Minimum detectable activity (MDA)—An *a priori* estimate of the activity that can be identified in a sample with 95% confidence under specified measurement conditions.

Minimum detectable contamination (MDC)—An *a priori* estimate of the activity concentration that can be identified with 95% confidence under a specified set of measurement conditions.

Non-ionizing radiation—Radiation lacking the energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves and visible light.

Nuclides—A general term used to denote the core, or nucleus, of all known atoms, both stable and unstable.

Neutrons—Neutral particles that are normally contained in the nucleus of all atoms, but may be removed by various interactions or processes like collision and fission.

Perched ground water –A layer of water-saturated sediment or rock separated from the underlying aquifer by unsaturated sediment or rock.

Perched water table—The upper surface of a body of perched water.

Percolation pond—Unlined wastewater pond where some of the water infiltrates into the ground.

pH—A measure of the acidity or alkalinity of a chemical solution; the negative log of the hydrogen ion concentration of a solution.

PM_{10}—All particulate matter in the ambient air with an aerodynamic diameter less than or equal to 10 micrometers. This size fraction is presumed to be respirable and is therefore of special interest.

Precision—A qualitative term used to describe the amount of random error in the measurement process, precision is a measure of the degree to which data generated from repeated measurements differ from one another.

Quality assurance—A management function that deals with setting policy and running an administrative system of management controls that cover planning, implementation, and review of data collection activities.

Quality control—Typically, all the scientific precautions, such as calibrations of equipment and duplicate sampling, that are needed to acquire data of known and adequate quality. Quality control is technical in nature and is implemented at the project level.

Radiation—Energy in transit in the form of high-speed particles and electromagnetic waves.

Radiation dose—The amount of energy deposited in biological tissues per weight of tissue.

Radioactive contamination—Radioactive material in an unwanted place.

Radioactive material—Any material that contains radioactive atoms.

Radioactivity—The spontaneous transformation of an unstable atom, which often results in the emission of radiation. This process is referred to as a transformation, a decay, or a disintegration of an atom.

Radioisotope—An unstable isotope or element that decays or disintegrates spontaneously, emitting radiation.

Radionuclide—A radioactive nuclide.

Sample variance—A measure of the dispersion of varieties observed in a sample expressed as a function of the squared deviations from the sample average.

Secondary maximum contaminant level—National drinking water standards regulating contaminants that primarily affect the aesthetic qualities of drinking water. At considerably higher concentrations, these contaminants may become health concerns.

Sigma (standard deviation)—A measure of the variability of a set of values; the square root of the variance.

Spent nuclear fuel—Nuclear fuel that has been removed from a reactor after use to produce power.

Split sample—The type of replicate sample produced when a laboratory divides one sample into subsamples.

Thermoluminescent dosimeter—A monitoring device that can be worn by an individual or placed in the environment to measure total gamma radiation during a period of time.

Transuranic waste—Waste that contains isotopes above uranium in the periodic table of chemical elements in levels exceeding 100 nanocuries per gram. Typically, transuranic waste contains by-products of fuel assembly, weapons fabrication, and/or reprocessing operations.

Tritium (H-3)—A radioactive isotope of hydrogen that has two neutrons and one proton in the nucleus.

X rays—Electromagnetic waves or photons not emitted from the nucleus, but normally emitted by energy changes in electrons. These energy changes occur either in electron orbital shells that surround an atom or during the process of slowing energy down, such as in an x-ray machine.

Acronyms

AIP—Agreement-in-principle

ANL-W—Argonne National Laboratory- West

BBWI—Bechtel BWXT Idaho, LLC

CERCLA—Comprehensive Environmental Response, Compensation, and Liability Act, also known as Superfund

CFA—Central Facilities Area

DOE—U.S. Department of Energy

DQO—Data Quality Objective

EIC—Electret ion chamber

EPA—U.S. Environmental Protection Agency

ESP—Environmental Surveillance Program

HPIC—High-pressure ionization chamber

IBL—State of Idaho Department of Health and Welfare Bureau of Laboratories

ICP—Inductively Coupled Plasma Emission Spectroscopy

INTEC—Idaho Nuclear Technology and Engineering Center (renamed in 1998 from Idaho Chemical Processing Plant).

INEEL—Idaho National Engineering and Environmental Laboratory

INEEL OP—Idaho National Engineering and Environmental Laboratory Oversight Program

ISU EML—Idaho State University Environmental Monitoring Laboratory

LMITCO—Lockheed Martin Idaho Technologies Company

MAPEP—Mixed Analyte Performance Evaluation Program

MCL—maximum contaminant level

MDA—minimum detectable activity

MDC—minimum detectable concentration

NIST—National Institute of Standards and Technology

QATF—Environmental Radiation Quality Assurance Task Force of the Pacific Northwest

NOAA—National Oceanic and Atmospheric Administration

NRF—Naval Reactors Facility

PBF—Power Burst Facility

QA—Quality Assurance

RCRA—Resource Conservation and Recovery Act

ROD—Record of Decision

RWMC—Radioactive Waste Management Complex

SB—Shoshone-Bannock Tribes

SMCL—secondary maximum contaminant level

TAN—Test Area North

TLD—Thermoluminescent Dosimeter

TRA—Test Reactor Area

USGS—U.S. Geological Survey

VOC—Volatile Organic Compounds

Units

Curie (Ci)—A unit used to measure radioactivity. One curie equals that quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units: thousandths (mCi), millionths (uCi), billionths (nCi), or trillionths (pCi) of a curie. The International Standard (SI) unit that is comparative to the curie is the becquerel (Bq). There are 3.7E10 Bq in one curie.

Rad—Acronym for radiation absorbed dose. The rad is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed by some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects from different radiations. The International Standard (SI) unit that is comparative to the rad is the gray (Gy). There are 100 rads in one gray.

Rem—Acronym for roentgen equivalent in man. The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or mrem. To determine equivalent dose (rem), the absorbed dose (rad) is multiplied by a quality factor (Q) that is unique to the type of incident radiation. The International Standard (SI) unit that is comparative to the rem is the sievert (Sv). There are 100 rem in one sievert.

Roentgen (R)—The roentgen is a unit used to measure a quantity called exposure, but only when used to describe an amount of gamma and X-rays in air. One roentgen is equal to depositing to 2.58E-4 coulombs of energy per kg of dry air, and is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and x-rays.

SI Prefixes—Many units are broken down into smaller units or expressed as multiples using standard metric prefixes. As examples, a kilobecquerel (kBq) is 1000 becquerels, a millirad (mrad) is a thousandth of a rad, a microrem (urem) is a millionth of a rem, a nanogram (ng) is a billionth of a gram, and a picocurie (pCi) is a trillionth of a curie.